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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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Specification and Workmanship equal to Main Line Locomotives.
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6145
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See Advertisement page 61.

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SHIPBUILDERS AND ENGINEERS,
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SPEEDS UP TO 45 MILES AN HOUR.
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Built complete with Steam, Oil or Petrol Motors, ; or Machinery supplied. Od 3551
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SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.
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Locomotives Tank Engines
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MANNING, WARDLE AND COMPANY, LIMITED,
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See their Illus. Advertisement, page 123, last week.

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See page 114, Dec. 14. 5734

RAILWAY CARRIAGES, ELECTRIC CARS, &c.
Hurst, Nelson & Co., Ltd.
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MACHINE BELTING
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NEW CAPSTANS, 1¼ in. through the wire feed.
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GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks & Mooring Buoys
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Tubes, Iron and Steel.
Edwin Lewis & Sons, Ltd.,
Wolverhampton. 5033

Tubes and Fittings.
—
Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 7. 4701

Rubber MANUFACTURERS
Belting
GUTTA PERCHA & RUBBER, LIMITED
Toronto Canada. 3918

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for Chemical & Mineral Water Mfrs. & Breweries.
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Fine Red Moulding Sand,
FOR
IRON, BRASS, ALUMINIUM.
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Steam Generating Sets for SALE:—
One 200 Kw., Willans-Mather & Platt, 220 volts or 440 volts.
Two 375 Kw., Willans-Siemens, 460/550 volts, D.C.
Engines triple expansion.
One Electric Capstan, 31 B.HP., 500 volts, D.C. motor.
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THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS and EVERY OTHER DESCRIPTION OF RAILWAY & TRAMWAY ROLLING STOCK,
Makers of WHEELS & AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON AND BRASS CASTINGS.
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London Office: 14, Londenhall Street, E.C.
See Illustrated Advt. in alternate issues. Od 3389

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(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
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Dredging Plant
OF ALL DESCRIPTIONS.
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See half-page Advertisement, last and next week.

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ENGINEERS, IRLAM, MANCHESTER,
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS. } Row's PATENTS.
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SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
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MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
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See Full Page Advt., page 81, Dec. 14.

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HALESOWEN. 6049

For Sale, Root's Blower.
A 5 in., with ring oiling bearings, fast and loose pulleys.
For Immediate Disposal.
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Forgings, Castings, Bars, Sheets, Wire, Tubes.
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Improved High Pressure
RENEWABLE DISC GLOBE VALVE.
See our Advertisement in last week's issue, page 30,
BRITISH STEAM SPECIALITIES, LTD.,
Bedford Street, Leicester. 3020

Machine and Engineering
WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROSSER & RUSSELL, Ltd., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9211

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Augustin-Normand
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Destroyers, Torpedo Boats, Yachts and Fast Boats.
Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Centrifugals.
—
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 6245
See half-page Advertisement page 80, Nov. 30.

The Manchester Steam Users' Association.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5884

East London College.

(University of London.)
Mile End Road, E. 1.
(Close to Stepney Green Station on the Underground Railway).

PRELIMINARY COURSE IN SCIENCE AND ENGINEERING FOR THE ROYAL AIR SERVICES.

The Course will be open to young men between 17 and 17½ years of age who have received a good general education, and as a general rule have attended either the public schools or secondary schools. Only these will be admitted who may be expected, after properly completing the Course and attaining the requisite age, to be reasonably certain of acceptation for the Officers' Cadet Wing (R.F.C.). The Course will commence on Tuesday, 15th January, 1918, and will extend for about six months, with a short vacation at Easter. The fee, during war time, will be Ten Guineas for the Course. A medical certificate will be required as a preliminary of admission to the Course.

The Course includes Lectures and Practical Work in Aeronautics; Physics; Electrical Engineering; Mechanics; Engineering Drawing; Aeroplane Engines; Meteorology; The Compass; Astronomy; also Workshop Practice.

As the accommodation in the First Term will be limited, applications for further particulars should be made at once to the Registrar, or to the Principal,

J. L. S. HATTON, M.A. J 807

Inst. C.E., I. Mech.E., B.Sc., and all Engineering Examinations.

—Mr. G. P. Knowles, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.E. Ben. I., prepares candidates personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 6398

TENDERS.

FOR DISPOSAL. HYDRAULIC PLANT.

Tenders are Invited for the

PURCHASE of the following HYDRAULIC PLANT, all of which is in good working order.

One 750 ton Press by Fullerton, Hodgart & Barclay, Paisley. Main Ram 36 in. diameter, 2 ft. 9 in. stroke. Jack Ram 6 in. diameter, 3 ft. 9 in. stroke. Traverse Ram 3½ in. diameter, 3 ft. stroke. Working pressure 1500 lbs. square inch.

One 300 ton Press by Hathorn, Davey & Co., Leeds. Main Ram 34 in. diameter, 2 ft. 6 in. stroke. Jack Ram 7½ in. diameter, 2 ft. 6 in. stroke. Working pressure 1600 lbs. per square inch.

One Three-throw Pump by Fullerton, Hodgart and Barclay. Rams 3½ in. diameter, 12 in. stroke, 60 revs. per minute, direct driven by 110 HP. motor through helical gears. Delivery 70 gallons per minute. Working pressure 1600 lbs. square inch.

One Accumulator by Hathorn, Davey & Co., Leeds, 13 in. diameter by 15 in. stroke. Working pressure 1500 lbs. square inch.

Three 300 ton Briquetting Presses. Unused.

Further particulars on application. — Address, J 770, Offices of Engineering.

CITY OF MANCHESTER.

The Electricity Committee of the Manchester Corporation are prepared to receive

Tenders for the Sale of the

following PLANT:—

(a) One 350 HP. Willans Engine, coupled to a 220 Kw. Electrical Co.'s Generator.

(b) Three Yates and Thom—A.E.G., 1500 Kw. Engine-Alternators.

The Plant is working daily, and may be inspected at the Stuart Street Generating Station.

Specifications of the Plant and Forms of Tender may be had from Mr. F. E. Hughes, Secretary, Electricity Department, Town Hall, Manchester.

Further particulars and information may be obtained from Mr. S. L. Pearce, Chief Engineer and Manager, Dickinson Street, Manchester.

Tenders, duly endorsed and addressed to the Chairman of the Electricity Committee, must be delivered at the Town Hall, not later than 10 a.m. on Wednesday, the 9th January, 1918.

The Corporation do not bind themselves to accept the highest or any tender.

THOMAS HUDSON,
Town Hall, Manchester, Town Clerk.
14th December, 1917. J 835

TO MAKERS OF STEAM TRACTORS.

The Metropolitan Asylums Board invite

Tenders for the Supply and

Delivery to Caterham Asylum, Surrey, of One Five-ton STEAM TRACTOR and Three Six-ton TRAILERS, in accordance with Specification prepared by Mr. T. Cooper, M.Inst.C.E., Acting Engineer-in-Chief.

The form of Tender, Contract and Specification may be inspected at the Office of the Board, Embankment, E.C. 4, on and after Ten a.m., on Saturday, 22nd December, 1917, and then can be obtained upon deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender.

Tenders addressed as noted on the form, must be delivered at the Office of the Board not later than Five p.m., on Thursday, the 10th January, 1918.

By Order,
T. DUNCOMBE MANN,
Clerk to the Board.
18th December, 1917. J 835

CITY OF LEEDS ELECTRICITY DEPARTMENT.

ENGINES, ALTERNATORS AND CONDENSING PLANT FOR SALE.

Offers are Invited for the

following PLANT, discarded to make room for larger sets:—

One 2000 B.HP. Triple Expansion, Three Cylinder Vertical BELLISS ENGINE.

One 2000 B.HP. Triple Expansion, Three Cylinder Vertical McLAREN ENGINE.

Two Sets Horizontal Surface CONDENSING PLANT, each having a cooling surface of 3400 square feet, with AIR PUMPING ENGINES and CIRCULATING ENGINES.

Two 1400 Kilowatt Two-phase ALTERNATORS and EXCITERS.

The plant is in good working order and can be inspected by appointment.

Offers will be considered for the whole or any part of the plant.

The Specification, &c., may be obtained from the undersigned.

The Corporation do not bind themselves to accept any offer.

Offers are to be addressed to "The Manager, Electricity Department, 1, Whitehall Road, Leeds."

C. NELSON HEYFORD,
1, Whitehall Road, Leeds, Manager.
20th December, 1917. J 836

APPOINTMENTS OPEN.

COUNTY BOROUGH OF BLACKBURN.

APPOINTMENT OF BOROUGH SURVEYOR AND WATER ENGINEER.

The Corporation of Blackburn invite

Applications for the Position

of BOROUGH SURVEYOR and WATER ENGINEER at a salary of £1000 per annum. The gentleman appointed will be required to devote the whole of his time to his duties, and will not be allowed to engage in private practice. Canvassing, either directly or indirectly, will be regarded as a disqualification, but printed copies of testimonials, may be forwarded to the members of the Selection Committee, a list of whom, together with a definition of duties applicable to the position, can be obtained on application to the undersigned.

The applications stating age, qualifications and experience, accompanied by copies of not more than three recent testimonials, and endorsed "Borough Surveyor and Water Engineer," to be sent to the undersigned not later than 12 o'clock at noon on Saturday, the 12th day of January, 1918.

Original testimonials must not be sent, and, if sent, will not be returned.

By Order,
Town Hall, LEWIS BEARD,
Blackburn, Town Clerk.
7th December, 1917. J 725

NEWCASTLE-UPON-TYNE EDUCATION COMMITTEE.

ATKINSON ROAD JUNIOR DAY TECHNICAL SCHOOL.

Wanted, in April, 1918, a

TEACHER OF ENGINEERING for the above-named school. Salary £200 per annum, rising by £10 per annum to a maximum of £300 per annum.

The teacher appointed may, if he so desires, avail himself of the provisions of the local Superannuation Scheme.

Application forms, to be obtained from the undersigned, will be received not later than 19th January, 1918.

PERCIVAL SHARP,
Director of Education. J 812

GUILDFORD EDUCATION COMMITTEE.
Acting for the Surrey County Council.

GUILDFORD JUNIOR TECHNICAL SCHOOL.

The Committee invite

Applications for the Appoint-

MENT of a TEMPORARY ASSISTANT MASTER to teach mainly Practical Mathematics. Duties to commence in January next. Commencing salary £160 per annum.

Applicants must be ineligible for Military Service.

Forms of application, which will be sent on receipt of a stamped addressed foolscap envelope, must be returned to the undersigned not later than 29th December, 1917.

F. G. SHIRLEY,
Acting Secretary.
Technical Institute,
Park Street, Guildford. J 840

NORTHAMPTON POLYTECHNIC INSTITUTE, CLERKENWELL, LONDON, E.C. 1.

Wanted at Once, an Assistant

LECTURER and DEMONSTRATOR in the Civil and Mechanical Engineering Department, with thorough practical and theoretical training in Mechanical Engineering. Commencing salary £150 per annum and war bonus. For conditions of appointment and particulars of duties apply to:

R. MULLINEUX WALMSLEY, D.Sc., J 837
Principal.

Teacher for Educational Work

in Engineering works—apprentices and other young persons. Good general and technical education; experience in workshops and teaching necessary. No one already engaged on Government work need apply.—Apply, giving full particulars of experience, age, medical category and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 843.

Rate Fixer Wanted, for

Machining and Assembling small scientific instruments. Practical experience in up-to-date methods essential.—Apply, with full particulars of experience, age, and salary required, to HOUGHTON-BUTCHER MFG. CO., Ltd., Clifford Road, Walthamstow, E. 17. J 815

Aeroplane Factory, N.W., has

VACANCY for a capable RATE FIXER, used to work in connection with light metal fittings, preferably, but not necessarily with previous experience of aircraft work. No one residing more than ten miles away or already engaged on Government work need write to BOX 670, Sells Ltd., 165, Fleet Street, E.C. 4. J 492

Metallurgical Chemist

REQUIRED for small Motor and Aero works. Must be used to alloy steels and preferably micro-photos. No person already on Government work will be engaged.—Apply, giving full particulars and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting reference No. A 4305. J 838

Gentleman Required by a

successful and progressive London Engineering Concern—Tool Experts with a large and valuable collection, and very good chances for development. Age not to exceed about 30. Free from Military service. No one on Government work to apply. Applicants must have had sound commercial and preferably some practical experience. Exceptional opportunity for the right man.—Applications, stating age, terms, full details as to past career, family, whether married, &c., to G, Box 898, care of Judds, 97, Gresham Street, E.C. 2. J 730

Resident Engineer Wanted,

at once, for Manchester district. Must be able to negotiate existing and new Government and other contracts, and to measure and prepare drawings of any site. Knowledge of lifting and transporting gear preferred, but not essential. State fully experience, age and salary required. No one employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 850.

Power Station Superintendent.

—A large Chemical Manufacturing Co. REQUIRE an ENGINEER experienced in large Power Station work to superintend the construction and operation of their power plant.

Applicants must have had a thorough training in this class of work, and have had experience with Marine Type Boilers and Turbine Units over 6000 Kw. capacity. Salary £400 per annum to commence. Only first-class men need apply, with copies of testimonials covering experience during past six years and stating when they can take up duties. No application will be received after the 28th instant.

Address, J 821, Offices of Engineering.

Works Manager Wanted, for

Works on N.E. Coast, manufacturing a speciality. Services of a man who has had experience in controlling male and female labour. Must be ineligible for Army. Good position for suitable man. Applications, which will be treated in confidence, should state experience, present occupation, age, and salary expected.—Address, J 822, Offices of Engineering.

Works Manager Wanted,

controlled London firm of instrument makers, about 1,000 employees. Good permanent opening for first-class trained engineer. Must have had previous experience as works manager and be a thoroughly good organiser. No one at present on Government work need apply.—State age, full experience, salary required, &c., BOX, No. 174, care of Reynood's, 150, Holborn, London, E.C. 1. J 824

Wanted, Assistant Works

MANAGER, over 45 or discharged, for large Glasgow concern. Practical knowledge of engineering desirable. Discharged Naval Engineer Officer might suit.—Address, stating age, experience and salary expected, 345, Wm. Porteous & Co., Advertising Agents, Glasgow. J 808

Inspector Wanted, to Keep

Oversight on and be responsible for all detail work from the machine shop of a controlled establishment, medium size work. To a good mechanic, possessed of tact and character, a good position is assured. No one employed on Government work will be engaged.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 758.

Cost Clerk Wanted, for

urgent Government work (Yorkshire district). Must be thoroughly experienced in analysis of weights and accounts, also on-cost charges, in connection with foundry and machine shops. Progressive position to steady, energetic man, capable of assisting the organising and working up of up-to-date cost systems. State age, experience and salary required. No person already employed on Government work will be engaged. — Applicants must apply to their nearest EMPLOYMENT EXCHANGE, mentioning Engineering and J 730.

Required for the Drawing

Office of a Government Department in London, CIVIL ENGINEERING ASSISTANTS. Must be good Draughtsmen and those familiar with dock, harbour and ferro-concrete work preferred. Should be ineligible for military service. — Apply, with particulars of experience, age, salary required, to BOX 919, care of Street's, 8, Serle Street, W.C. J 750

Wanted, as Soon as Possible,

a Smart, Up-to-date Jig and Tool DESIGNER, capable of checking tool drawings, in large works in West London. Must have had good all-round experience and be a good mathematician. Only those not already on Government work and residing within a ten-mile radius need apply, stating age, salary and experience.—Address, J 740, Offices of Engineering.

Required, for Government

Factory, an ELECTRICAL ENGINEER, with good mechanical engineering training, for test and investigation work on electrical ignition. Knowledge of petrol engines is desirable. No person already on Government work will be engaged.—Apply, stating salary required and giving particulars of experience, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4177 and this Journal. J 664

Draughtsmen.—Several Com-

petent WANTED, on Electrical Motor Control Gear, London district. No person living more than ten miles away or already on Government work engaged.—Apply, stating age, experience, including works experience, and salary required, to J 736, Offices of Engineering.

Draughtsman Wanted,

immediately for Government work. Knowledge of Mechanics, Design and Power Drive.—Full particulars.—Address, J 855, Offices of Engineering.

Chief Draughtsman Wanted,

for Controlled Establishment in West Riding of Yorkshire, manufacturing Petrol-driven Commercial Motor Vehicles.

Only those having previous first-class experience need apply, and no person already on Government work will be engaged.

Apply, in first instance, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4206, and stating particulars of experience, age and salary expected. J 690

Reinforced Concrete Con-

STRUCTION is of National Importance for Munition Works and Shipbuilding.

THE TRUSSED CONCRETE STEEL CO., Ltd., of Caxton House, Westminster, S.W. 1, are in NEED of DESIGNERS.

Experienced Engineers are invited to apply for positions, in first place, by letter. Preference given to men with University qualifications. No one residing more than ten miles away or already engaged on Government work need apply. J 836

Draughtsmen, with Experi-

ence in coke oven plant, coal-handling machinery, and chemical or tar plants, WANTED Immediately.—Apply, stating experience, age, and salary required, to KOPPERS' COKE OVEN AND BYE PRODUCT CO., 301, Glossop Road, Sheffield. No one already employed on Government work will be engaged. J 348

Draughtsman Required, pre-

ferably with a knowledge of steam cranes, used to making detailed drawings. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 809.

Draughtsman Wanted, for

Designing and Drawing Offices of a large shipbuilding works on West Coast. No person already on Government work will be engaged.—Applicants should state salary and experience to their nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 4265. J 820

Draughtsman for Tool and

Jig work, also for planning and production departments, urgently REQUIRED in large factory; excellent prospects. No person engaged on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4171 and this Journal. J 657

Draughtsmen Wanted for

Aeroplane work in Government Factory. Previous experience in aeroplane design not absolutely necessary, but sound knowledge of mechanical principles essential. Good prospects for right men. No person already on Government work will be engaged.—Apply, stating experience, age, and salary required, to your nearest EMPLOYMENT EXCHANGE quoting reference No. A. 4126 and this Journal. J 626

Draughtsman Required, with

first-class experience in jigs, tools and machine work, for Shell Factory. Production bonus given. State age and salary required. No one engaged on Government work or residing more than ten miles from N.E. London need apply.—Address, J 807, Offices of Engineering.

Leading Draughtsman Wanted

for Aeroplane Drawing Office, to be responsible under chief draughtsman for preparation and checking of detail drawings for new machines. No person already on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4190. J 823

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KEADBY RAILWAY AND HIGHWAY SCHERZER ROLLER LIFT BRIDGE.

(*Concluded from page 594.*)

WE conclude our series of illustrations of the Keadby Bridge, by giving details of the operating machinery and signals system, on Plates LXII to LXV. The key plan, elevation and detail plans on Plate LXII, show the general arrangement of the electric-power station, battery house, operating machinery, and operator's cabin. On Plate LXIII there are given details of the rack supports on the rolling lift span; on Plate LXIV, details of the racking machinery and signal semaphores; on Plate LXV are two perspective views—one (Fig. 122) in the power house, and the other (Fig. 123) in the operators' cabin.

The lifting span, which is the heaviest yet constructed in Europe, having a total weight of, approximately, 3,000 tons, is worked electrically by two 115-h.p. compound wound motors carried on the leaf itself, the power being transmitted through spur gearing to the operating pinions at each side of the moving leaf. (Figs. 114 to 117.) These pinions, which are at the centre of roll of the leaf, engage with horizontal fixed racks, mounted on braced supports carried on piers. The length of these racks, 40 ft., is equal to the travel of the pinion necessary to open the bridge to its fullest extent, namely, through a vertical angle of 81 degrees 51 minutes. The time taken to open or close the bridge by electrical power is less than two minutes. Owing to the operating machinery being fixed on the moving leaf, it was necessary in designing it to consider the machinery in a vertical as well as a horizontal plane.

To provide against any failure of the current or considerable repairs to the electrical machinery, a 50-h.p. petrol engine is installed on the operating platform, alongside the bridge. (Fig. 106.) This engine drives a vertical shaft, fitted with bevel gears operating a revolving square shaft, which is parallel with the rack, and is supported on tumbler bearings. This shaft drives a sleeve mounted with bevel gears driving a cross shaft to the differential gear, and so back to the main pinions at the racks. The sleeve is carried off the main gudgeon pin and is free to slide along the square shaft as the leaf rolls. A hand winch, intended for construction purposes, is also provided on the operating platform, working through the auxiliary gears, and although not intended as a stand-by, proved of very great value during the various tests which were made after erection in order to ascertain the balance of the leaf.

The absence of any supply of electric power in the neighbourhood of the bridge rendered it necessary to put down a special plant for the generation of electrical energy. This plant, situated under the land span on the east bank of the river (Figs. 105 and 106), consists of two direct-coupled petrol-engine generators supplying a storage battery; the normal method of working is direct from the battery, the current being delivered to the switchboards at 220 volts. The main generators, which are in duplicate, are 50 kw. continuous current machines of the British Thomson-Houston Company's six-pole semi-enclosed type, each driven by a 70-b.h.p. four-cylinder vertical Allen petrol engine, running at 700 rvs. per minute. The engines are water-jacketed, and, owing to the lack of a water supply in the neighbourhood, and the unsuitability of the crude river water for this purpose, a small pumping plant had to be put down, and the water filtered and purified for use. A perspective view of the interior of the power house is given on Plate LXV.

The battery (Fig. 106), which was supplied by the Chloride Electric Storage Company, Limited, is capable of supplying the main motors with current for about thirty movements of the bridge without running the engines and generators. This means, in practice, that the battery has to be recharged about once a week. The battery consists of 128 "Plantide" cells, and when fully charged it is capable of giving a discharge of 855 amperes for one hour, or 1,710 amperes for three minutes. The normal charging rate of the battery is 288 amperes, and the maximum charging rate 360 amperes. The maximum charging voltage is 2.75 volts per cell. The ampere hour efficiency is 90 per cent., and the watt hour efficiency 70 per cent. The battery itself is contained in a specially-built battery house on the north side of the land span, adjoining the generator house. The approximate weight of the complete battery, exclusive of stands, is 45½ tons.

The machinery on the moving leaf is shown in detail in Figs. 114 to 117. Situated on the moving leaf there are two motors of The British Thomson-Houston Company's make, compound wound and totally enclosed, and each capable of developing 115 h.p. on a 220-volt circuit at a normal speed of 380 revs. per minute, and designed to withstand an overload of 100 per cent. for a period of three minutes without injurious heating. They are coupled directly to the driving-pinion shaft by means of flexible couplings, and are so arranged as to work either singly or in parallel, as the exigencies of working may require. These motors are fitted with ball bearings, and are capable of being turned through an angle of 90 degrees.

Two independent solenoid brakes of the double-clip type, operated in parallel, are arranged on the motor shaft; these are set by powerful springs and released by shunt-wound solenoids, each capable of exerting a pull of 360 lb. through a stroke of 6 in. so that in the event of failure or cut-off of the current they come into action automatically, and have a maximum holding power of 50 per cent. in excess of the torque developed by the motors at their rated capacity. Auxiliary brakes are fixed on the second motion shaft, and are of the band type. These brakes are released by a 1-h.p. motor, working with a rack and pinion, and coupled by levers to the two brake drums through a compensating link to ensure both drums taking an equal effort; they are set by powerful springs, which come automatically into action on the failure or cut-off of the current. The operating motor is capable of exerting a pull of 525 lbs. through 7 in. The solenoid brakes are energised on the first-brake step, and remain energised on all subsequent steps; but the release of the auxiliary brake, which commences on the second brake step, is graduated through the succeeding steps until the fully "off" step is reached on No. 7, which provides a free-coasting point. Thus in starting to raise the bridge by moving the master controller handle from the "off" position, the holding power of this brake is gradually reduced as each of the successive brake notches is passed. All the brakes are fitted with hand releases designed for use when it is desired to work the bridge by means of the auxiliary operating gear. Springs for applying the brakes were fitted, in place of weights, owing to these brakes having to rotate through the angular movement of the leaf. An oil dash-pot is fitted to the auxiliary brake, so that the brake is applied gradually, and thus eliminates any shock to the gears.

The differential gear is fitted on the second-motion shaft, and is of the spur type mounted on a spider frame fixed to the driving wheel, which engages with the motor pinion. The second-motion shaft is split at this point, each portion extending to one side of the leaf, and engaging with the main-spur gears. The object of the differential gear is to ensure that each rolling pinion takes an equal share of the loading, thus equalising the torque on the shafts. The whole of this gear, including the pinion on the motor shaft, is enclosed in a cast-iron gear case partially filled with oil.

The clutch-operating gear changing from the main drive to the auxiliary drive is also fitted on this gear case. This change can be effected without losing control of the leaf as the auxiliary clutch must engage before the main clutch is free. Thus the brakes retain full control of the leaf during this operation. An indicator is fitted showing the "clutch in" and "clutch out."

The main motors, brakes and differential gear are enclosed in a weatherproof machinery house fitted with electric light, the whole being fixed to a frame, forming one unit, and attached to the cross members leading to the counterweight. (Fig. 105.) Access to this house is by means of ladders and gangways leading from the operator's platform.

All gears, including the rolling pinions and racks, are machine cut, and up to 3-in. pitch, were of 15 deg. involute shape; above 3-in. pitch the teeth are of special design. All gears are made of steel. The rolling pinions are 7¾-in. pitch, 23-in. face In designing these gears the resulting maximum stresses were calculated to meet the case of a 20-lb. normal-wind pressure over the entire area of the raised leaf, which represents a horizontal thrust of 153 tons on each of the racks.

The whole of the electrical operation of the bridge is governed by a master controller of the drum type, provided with seven brake and seven power steps. The contactor panel is arranged for plain parallel control, so that either motor may be cut off at will. There are 16 contactors on this panel for use with the two main motors, and one small contactor mounted on the back of the panel for operating the two main brake magnets. This panel, although shown in the operator's cabin, was ultimately put below the cabin floor along with the resistances.

Under normal conditions it is possible to raise the bridge with one motor only, and the attached record of power-tests, carried out on the bridge under ordinary working conditions, shows the effort required and the current consumption involved during the operations of raising and lowering the leaf.

Power Test. (Current supplied direct from Main Battery.)

Test No.	Amperes.	Volts	Time.	Degrees of Travel.	Remarks.	Current at Starting when Notching Up.
			min. sec.			amperes
1	210	235	1 50	0 to 70	Two motors lifting	250 to 300
2	100	235	1 50	70 to 2	Both motors lowering	200 to 250
3	—	—	0 16	2 to 0	Both motors lowering on diverter control	
4	180	235	1 50	0 to 70	No. 1 motor lifting	300 to 350
5	60	235	1 48	70 to 2	No. 1 motor lowering	250 to 300
6	120	235	0 17	2 to 0	No. 1 motor lowering on diverter control	
7	180	235	1 13	0 to 45	No. 2 motor lifting	
8	60	235	1 8	45 to 2	No. 2 motor lowering	
9	120	235	0 18	2 to 0	No. 2 motor lowering on diverter control	

At the time these tests were made there was practically no wind.

The sources of power available for raising the bridge are: (1) The main battery with either one or two motors. (2) The main generators, either singly or in parallel. (3) The auxiliary petrol engine. Cable connections from the distributing panels lead to the operating or control panel and thence through the main contactor panel to the motor connections on the bridge itself. Electrical connection between the fixed and moving elements of the bridge is by flexible rubber sheathed conductors. These cables are so arranged that when the bridge is down they rest in steel troughs, fixed alongside the track-girders and are lifted out in long and easy curves when the bridge is raised.

The master controller is fitted with an electro-mechanical lock controlled by the king lever on the signal frame, which prevents the handle from being moved until all railway signals are set at "Danger" and the gates are closed to traffic. Similarly, until the controller is brought to the "Off" position the signalling circuits are intercepted and normal traffic working cannot be resumed.

A reversing barrel is provided in the master controller for the lifting and lowering operations respectively, and the reversal of motion in the motors is effected by means of a solenoid-operated pole-changer working in connection therewith, the function of which is to commutate the connections of the two motors for the forward and reverse directions of rotation corresponding to lifting and lowering. A limit switch of the screw type is provided on the bridge leaf, fitted with contacts set to correspond with a vertical lift angle of 70 deg., at which point all power is cut off and all brakes applied. In lowering the bridge full power is available under the control of the operator from maximum elevation to a pre-determined point corresponding with an angle of lift of about 3 deg. When the descending leaf reaches this position a

set of contacts comes into operation which results in a reduction of speed and power, followed immediately by the action of a second switch, which applies the full braking power and arrests the downward movement of the leaf. Beyond this point, in order to complete the final travel, a pedal switch is brought into use, with which only a minimum amount of power is available to bring the leaf to the closed position. The reduction of speed by means of the diverter or pedal switch is clearly shown in the record of power tests. Comparing tests Nos. 2 and 3, in the preceding Table, the speed of roll is 68 deg. in 1 min. 50 secs., or 1 deg. in 1.6 seconds, while in Test No. 3 the speed is 2 deg. in 16 seconds, or 1 deg. in 8 seconds. That is, by means of the diverter, the bridge is made to "creep" down to its bearing blocks, and so to avoid any harmful bump. This is most important, as will be obvious if the inertia of this rolling mass be estimated even at moderate speeds. It should be noted that the diverter comes into circuit automatically by the action of the limit switches, so that the leaf can be brought to the bearing blocks only at a creeping speed. The arrangement is therefore "fool proof." There is an air buffer fixed under the nose of the lifting leaf and this buffer comes into operation and checks the motion, the pedal switch being kept depressed until the brakes have been fully applied.

In the operator's cabin there is, in full view of the operator, a mechanical indicator actuated from the rolling pinion of the bridge, which indicates by means of an arm moving over a graduated arc, the angular elevation of the leaf at any instant. Single stroke gongs operated therefrom call the attention of the operator to the "nearly open" and "nearly closed" position of the leaf.

The two locking bolts at the nose of the leaf are electrically operated through spur gearing by means of a motor of 1½ h.p. totally enclosed series wound and fitted with ball bearings. This operation is interlocked with the signalling system. The rear gates on the land span are electrically operated, but hand operation is also provided to be used in case of emergency. The rear gate operating gear is situated in the operator's cabin, the gates being driven by means of spur gearing and rods and levers. The motor is 4½ h.p. totally enclosed compound wound, and drives through a horizontal worm drive fitted with a slipping clutch. Two rear buffers are carried off the two outside land span girders and come into operation when the bridge is nearing the fully open position. These buffers are of the hydraulic pneumatic type. The ram is depressed when the striking bracket fixed on counterweight comes into contact as the leaf is opening. When the leaf is being closed this load is released and the ram returns to the full out position.

The signalling problem faced was how to handle safely three classes of traffic, namely, by road, river, and rail. These are co-ordinated in a general scheme of signalling, bridge-bolting, detecting, gate locking and track circuiting, an all-electric system, being centralised in a 28 lever interlocking frame in the operator's cabin (Fig. 123). This cabin on the bridge is so situated on the north side of the track span (Fig. 106) as to command a good view of the road, railway and river for the proper control of traffic. The controlling arrangements for the leaf are necessarily of a complicated nature, for the bridge has to be bolted at the nose and the correct alignment of its rails with the rails on the fixed spans has to be ensured by cross plunging and detection at both nose and heel before road or railway traffic can pass over the bridge.

For the protection of road traffic, the electrically-operated gates on the east side and the hand-operated gate on the west side, are locked or released by stops controlled electrically from the cabin. Road warning signals are given from the cabin by electric gongs on each of the approach-roads leading to the bridge when the leaf is about to be raised.

The cabin controls the river traffic by means of special signal lights, some of which change colour at night to indicate to vessels the position of the leaf ("up" and "down"), a hand-worked ball signal being used for the same purpose in the day time.

In opening the leaf for river traffic, the following lever movements take place. (1) The road-warning lever is pulled, causing a gong to ring at each of the warning signs: the gongs continue to ring until the gates are nearly closed across the roadway. At night the signs are illuminated and display the word "Danger." (2) A second lever, released by No. 1 when pulled, operates the gate stops controlling the gates on both the east and west sides, enabling them to be moved. (3) The levers controlling the sand drags, when pulled, trap the up and down lines in the facing direction of traffic on each side of the bridge. (4) This enables the rail-detector levers to be pulled, withdrawing the plungers from the rail ends, at the same time the various electrical circuits across the bridge are broken, and the correct working of the operating connections having been obtained, an automatic indication is similarly given. (5) When No. 4 has been correctly worked, the lever controlling the bridge bolts can be pulled and the bridge-bolts withdrawn, and when this has been accomplished, return indication is given back to the cabin in a similar manner. (6) The last operation necessary before the bridge itself is free to be raised is the pulling of the king lever in the signal frame. This lever is released by the proper working of the lever immediately preceding it, and when pulled, it releases the electro-mechanical lock in the master controller, which in turn, when properly released, makes a contact completing the 220-volt circuit for the operation of the clapper switch coils through the medium of the controller. The actual lifting of the leaf is then carried out by operating the controller handle previously referred to.

To lower the bridge for normal traffic, the sequence of movements of the above-mentioned levers is reversed, all lever movements, both for lifting and lowering the leaf, being interlocked with one another in such a way that the operation can only be accomplished in the definite order stated.

The use of three position upper-quadrant signals present many interesting features, and the diagrams, Figs. 119 to 121, on Plate LXIV, show the various positions.

Tall steel masts carrying an overhead cable 110 ft. above high water connect the signalling circuits on each side of the river when the bridge is raised. The availability of electric power thus enabled an all-electric system of railway signalling to be used and the new deviation line on which the bridge stands is the first piece of railway in this country upon which the three-position system of signalling has been installed.

In concluding our description of the bridge and the mechanism for operating the roller-lift span we desire again to express our thanks to the engineer, Mr. J. B. Ball, M.Inst.C.E., for his permission to illustrate and describe the work so fully, and to Sir William Arrol and Co., Limited, Mr. Adam Hunter, one of their directors who was closely identified with the work, and to Mr. J. H. Nicholson, Assoc.M.Inst.C.E., their resident engineer, for assistance in preparing our articles. Our thanks are also due to Mr. A. G. Gardner, Assoc-M.Inst.C.E., Mr. Ball's assistant.

THE INSTITUTION OF MECHANICAL ENGINEERS.

An ordinary general meeting of the above Institution was held on Friday last, the 14th inst., at the Institution of Civil Engineers, Great George-street, Westminster, the chair being occupied by the President, Mr. Michael Longridge.

After the usual preliminary business, Mr. Longridge announced that the Council had elected Dr. Edw. Hopkinson as Member of Council, to fill the place left vacant by the death of Mr. Charles Hawksley. Dr. Hopkinson would retire at the next annual general meeting, according to the Articles of Association, and would be eligible for re-election.

New Elections and Transferences.

The Secretary then stated that the Council had that afternoon opened the ballot list, and found that 87 candidates had been elected to the various grades of membership, while five transferences had been made from the class of Associate Member to that of full member.

Soap Films and Torsion Problems.

The paper set down for reading and discussion was one entitled "The Use of Soap Films in Solving Torsion Problems," by A. A. Griffith, M.Eng., of South Farnborough, and G. J. Taylor, M.A., of London. We commence the publication of this paper in full on page 652 of the present issue, and therefore proceed to the discussion.

Mr. Taylor, prior to reading the paper in abstract, referred, in the following terms, to the origin of the investigation. He stated that about a year ago those who were responsible for the strength calculations at the Royal Aircraft Factory at Farnborough were somewhat exercised as to methods of calculating the stress in twisted members. It was not only interesting to know the distribution of stress in these cases, but also the angle through which the various members twisted. This was particularly true of propeller blades, in the design of which a point of great importance to consider was their ability to resist twisting under stress. It therefore became necessary so to design the section that the observed distribution of pressure would come on the face of the blade. The blade should not twist, as, if it did so, the efficiency of the propeller would be impaired. The methods of calculating stresses in twisted cylinders were originated by St. Venant, who obtained mathematical equations for finding the stress and the torque when a cylindrical body of any cross section was twisted. He reduced the problem to finding the solution of a certain differential equation. This differential equation he was able to solve in certain special cases, such as the square or the triangle, but for most of the cases in which the solution was needed it was impossible to solve it. An odd-shaped section, like that of a propeller blade, was apparently a stumbling block to mathematicians. Knowing that the speaker had done certain work in connection with physics and mathematics, the authorities at Farnborough asked if he could help in any way. In Love's book on elasticity it was remarked that the equations which prescribed completely the stresses and torque of a twisted cylinder were of exactly the same mathematical form as the equations for the case of a deformed soap bubble. Not much was said about soap bubbles; allusion was merely made to the equivalents which represented the deformation of an evenly loaded elastic membrane. As such a membrane, the soap bubble was ideal. It was easier to measure the deformation of a soap bubble than to measure the stresses and torque in a twisted cylinder, although, being the same equations, the mathematical difficulties were the same. It appeared, however, that by measuring an initially flat soap film when a difference of pressure was applied to the two sides of it, it became possible to find theoretically the stresses in a twisted bar of the same section as the edge of the soap film. He had tried this by cutting an elliptical hole in the bottom of a tin, stretching a soap film over the hole, inverting the tin over a basin, and pouring water into the bottom of the basin. As the water was poured in the basin, the liquid rose in the tin and blew a slightly deformed bubble in the soap film. On observing the bubble, it seemed quite possible to measure the angle of deformation—that was to say, the angle between the plane of the hole and the soap film. At that stage of investigation, the speaker had to leave Farnborough, and Mr. Griffith had taken the matter up and devised the apparatus for measuring the soap film illustrated in the paper. To Mr. Griffith were due also most of the results set out in the body of the paper.

The President opened the discussion, remarking that he had found much in this interesting and original paper which he could not wholly understand, particularly the latter part, relating to "compound" sections. He understood that the equations dealing with the displacement of an elastic film were based upon the assumption that the film was of uniform thickness all over. He questioned, however, whether a soap bubble film was of uniform thickness all over; he believed it was usually a good deal thicker at the top than down below, a circumstance which might affect the validity of the argument which the authors advanced.

Mr. Henry Fowler, C.B.E., who spoke next,

explained that the work which was the subject of the paper had been carried out in the factory which he was at present superintending, and was the result of the impossibility of dealing mathematically with many of the problems arising in the aeronautical industry. In solving these problems, the authors had conferred great benefit upon that industry and upon the engineering industry generally. The results recorded in the paper were of undoubted use to engineers whose mathematics, like his own, had worn somewhat thin. The Advisory Committee on Aeronautics, before whom the results had been laid, regarded the paper as of such importance that they considered it should be presented to the engineering profession at the earliest opportunity, and the speaker shared the opinion of the Committee that this end could not be better attained than by the aid of the Institution of Mechanical Engineers. The soap bubble was already of growing utility in solving problems hitherto insoluble from the standpoint of practice. He regretted that the method by which the contour lines were accurately ascertained—about which there was some question—could not be thrown on the screen, as, if this had been possible, he believed it would have been shown that an accuracy of one-thousandth of an inch in the fit between the end of the pointer and the soap bubble could be depended upon, without breaking the bubble. The apparatus, if complicated in description, was simple to manipulate. Mr. Taylor had spoken of the air-screw or propeller, in which, to prevent deformation, stiffness was a first essential, and here the method described in the paper was of great use. He had been asked to apply the method experimentally to certain engine crankshafts and propeller shafts which had given trouble, and he felt sure that had that method been applied in these cases before the design was put forward the trouble would not have occurred; an inspection of the shape of the soap bubble would have anticipated the effects of torsion. He trusted that Dr. Gibson (whom he saw present) would continue the work which he and Mr. Ritchie had already carried out in relation to structures. It was, for instance, frequently necessary to support shafting from part of the roof principals, which involved certain torsional stresses likely to set up trouble. Here again, the use of the authors' method would show the probability of the structure being able to endure these torsional stresses. With regard to the difficulty (mentioned by Mr. Taylor) of the sharp corner, all engineers knew the means for getting over this difficulty, but the method under discussion would indicate the nature of the difficulty to be overcome. Mr. Taylor had also made the apparently startling statement that the cutting away of metal from a structure might strengthen it, a fact exemplified in the case of an angle, where the resistance to torsion was increased not by filling in metal, but by taking a portion out of the corner of the section.

Professor A. H. Gibson considered that the paper marked the only real advance in knowledge of the general properties of the torsion of a section since the days of St. Venant. The authors were mainly interested in aeronautical engineering, but speaking for himself, as one who had been and hoped again to be interested in structural engineering, he regarded the paper as even more important from the point of view of structural and mechanical engineering. Referring to the torsion stresses in ordinary commercial rolled sections, he would say that in the case of attempting to load a straight beam uniformly, some little torsion was generally present; but when loads were applied eccentrically the torsion forces present were large, while torsion became a very important factor if the case were taken of a beam that was not straight, such as employed in the circle at a theatre, where the supports were at intervals with uniform loading in between. He wondered whether engineers generally realised that up to about three or four years ago there were very few data on which to design such sections with any degree of exactitude, although a few isolated experiments had been made in this country and in Germany. In 1913, Mr. Ritchie carried out a rather elaborate series of tests of all sorts on commercial sections, and determined the torque, or the angular displacement in terms of the applied torque. That furnished something to go upon. But even Mr. Ritchie's work did not enable the stress at any point of such a section to be determined, and it was necessary to have recourse to the work of Bach and Autenrieth. That work had proved particularly satisfactory in another case, but it was mainly guesswork. By the authors' method, however, it was possible not only to obtain the angular twist corresponding to a given torque, but also the stress at every point of the section. In view of the fact that this could be done so easily, and he might add so cheaply, it became highly important to ascertain, by this means, the values for the majority of the commercial sections. He ventured to suggest that either the Engineering Standards Committee or the Research Committee of the Institution of Mechanical Engineers should consider the question of having the values for the various standard sections tabulated; it would, he thought, be worth the trouble expended. Turning to the paper itself, he desired, in the first place, to refer to Table IV, showing the Effect of Rounding the Internal Corner on the Strength of a Twisted L-Shaped Angle Beam. As most engineers would expect, the section was distinctly strengthened by increasing the radius of the curve at the inner corner. It was, however, surprising that after reaching a radius of about 0.7 of the thickness of the arm any addition to the radius caused the section to become distinctly weaker. He could not say whether he was correct in his interpretation. It would be noticed that towards the end of the table, as the radius became large, the increase in the ratio of the maximum stress to the stress in the arm became greater. It would be interesting if the radius could be made even larger, so that the development of the curve might be noted after the radius had become twice the thickness of the arm. It was not clear to him whether he was to understand that in an angle subject to a given torque the maximum stress increased as the ratio increased beyond 0.7, and at first sight this would appear improbable. Was it not really the case that the mean stress in the arm was reduced by the addition of material in the corner, so that, in spite of the increase in ratio given in column 2 of the table, the maximum stress in the section became smaller as the radius became greater. Perhaps the authors would say whether that were so, or whether the figures meant what they appeared to mean, namely, that the maximum stress did actually keep on increasing as the radius of the fillet increased. That would also appear to be implied in the closing paragraph of the paper, where it was stated that "the stress at any point of a rolled standard section may be taken to be $2a$ NT, where a is the radius of the inscribed circle which touches at that point." If the section were drawn out, it would be found that as the radius of the section was increased the radius of the circle also increased. That implied that increasing the size of the fillet between web and flange of an ordinary I-section increased the stress of that section under a given twist. Did that also apply under a given torque? [Mr. Taylor here intimated that it did not.] Professor Gibson went on to say that the engineer required to know what the stress would be under a given torque and not under a given twist. Referring to Table IX of the paper, he believed that all the experimental work for that table was done by Mr. Ritchie, and he had himself been working out the value of C by the author's formula. Taking the first two items (angles) and the last item (channel), each could be imagined to consist of a straight thin piece of metal bent round so as to form the section under consideration. Using the authors' simple formula $C = \frac{1}{3}\int_0^2 y^3 \, dx = 1$, for the torsional stiffness of any long thin section, he obtained results identical with those given by the author, and he assumed that formula to be the one used by the authors in computing the values they had obtained; if it were not, it agreed well with the results. In the case, however, of Sections 3, 4, 5 and 6 (tees and I-beams), he would be glad to learn what formula the authors used, and to what extent (if at all) they deemed it possible to apply to such sections the simple formula he had quoted, as in the case of an I-beam or a tee this formula did not appear to be valid, the results showing a difference of about 30 per cent.

Mr. L. Bairstow was the next speaker. He thought that the experiments made and recorded by Mr. Taylor and Mr. Griffiths illustrated a tendency among engineers to take up problems left by the mathematicians as non-solvable. In some cases the soap film method could assume the relation of the slide rule to a book of problems of the ordinary mathematical kind; to a certain degree it afforded approximate results more rapidly than the mathematical method. On the other hand, there were many instances of problems to which the soap film was almost equally applicable, but which had been given up by the mathematicians. The illustrations of torsion given by the authors, and those relating to flexure, were really only particular cases of a much more general problem, which could be solved by a combination of the mathematical and soap film methods. Assuming the pressure on the soap film to be variable from point to point instead of being uniform, it was clear that there was no simple means of applying a non-uniform pressure to the soap film; but that could be tackled by a standard piece of mathematical analysis. Mathematical analysis alone was sufficient in many cases. He would instance the eddying motion of a viscous fluid behind a cylinder. Given the distribution of vortexity round the whole field, it was possible to determine the stream lines of the motion entirely by calculation. A part of that problem might, as a matter of fact, be done by the soap film. Most members would recall the diagrams obtained by Dr. Hele-Shaw when glycerine was forced between two plates of glass, and coloured streaks were projected on a screen and measured. That problem was, in some respects, exactly analogous to the kind of problem which could be solved by the soap film; but, of necessity, it always corresponded to cases in which the pressure was zero. To get the curvature of the soap films in correspondence with the stream lines, it was necessary to build up the curve boundary much in the manner adopted by the authors for angles or beams. If the method were looked upon as an engineering subject, he thought it would get rid of much calculation of spheric harmonics and Bessel functions, all of which were involved in such cases as the mathematician could deal with. He rather thought that the authors had overlooked the work done by M. Marcel Brillouin, of Paris. The authors had suggested that the section of a propeller plate was not amenable to strict mathematical analysis. It was quite true that the majority of the mathematical methods were applicable only to spheres or cylinders, but M. Brillouin had found that sections not having a cylindrical form could be subjected to a rigid mathematical analysis. It had been argued, however, with some point, that the method was not fully proved, but it was sufficiently good to warrant further investigation. In conclusion, he was pleased to see that methods of tackling experimentally some of the difficult problems in mathematical physics were coming forward and being taken up by engineers.

Dr. Hele-Shaw thought that probably nothing was so interesting in the progress of science as the methods which in recent years had thrown light upon the relation between the particles of matter in directions which formerly seemed hopelessly obscure. He instanced the value of microphotography in showing the behaviour of materials under stress and Professor Coker's employment of polarised light in connection with sheets of xylonite or celluloid. With regard to the investigation of the behaviour of particles by the use of thin films between plates, he might repeat an illustration he had formerly made to show the minuteness of the particles and the hopelessness of actually seeing their operations. If these particles were to enter an ordinary drinking glass at the rate of one million a second it would take 47,000,000 years to fill the glass. The approach to a discovery was often opposite in direction. The behaviour of the thin films—bands of colour with clear glycerine—apparently gave similar lines to the round sections of cylinders and ellipses worked upon by Poisson, Kelvin and Clerk Maxwell. When worked out by

calculation they were found to agree exactly, and Sir Gabriel Stokes had proved that the correspondence was mathematically true. The method was afterwards applied to electrical matters (the magnetic field and so on) with which mathematicians were capable of dealing. The paper under discussion was, however, an instance of the exact opposite, since it was a case of seeing something like a result, and, by investigation, finding it correct. The authors had shown that such an instance must be rare; no one could have seen that the contour of a soap bubble hanging to an orifice represented torsion, and scarcely an imagination like Mr. Taylor's would have dreamed that the outcome was this, that the partial differential equation for torsion was found to be the same as the equation for the surface of a soap bubble film. Great credit was due to Mr. Taylor for seeing that mathematical methods could be devised whereby the relation could be utilised. The apparatus devised by Mr. Griffith for measuring and plotting the contour lines of the pendant soap film was remarkable. At present, however, it could not be used in the same manner as Professor Coker's apparatus, but probably some method of so utilising it would be devised later. The speaker referred to the labour involved in following point by point the curved surface in order to plot the pendant film, and thereby obtain indication of the stresses according as the contour lines approached each other, stiffness, as all engineers knew, being indicated by close proximity of these contour lines. Another creditable piece of work was the determination of the volume of the soap bubble to get the total torque. He felt it right, as a Member of the Council, to say, that a great compliment had been paid to the Institution of Mechanical Engineers in having such a paper as that under discussion presented to them in the first instance. He had read the paper from end to end, and found the formulæ clear and simple. The explanation at the end was so put that anyone with any knowledge of the calculus could follow it.

Mr. J. J. Guest remarked that mathematicians occasionally made startling discoveries. He would cite the instance of Clerk Maxwell, who made a startling discovery as to the ratio of two constants. Yet it took many years before that discovery led to any practical result. In the present case, however, theory and practice were coincident, and Mr. Taylor's discovery had been useful at a critical time. The paper was, he considered, extremely important, and should be taken in conjunction with the optical method of determining stress. The optical method solved certain problems in bending very beautifully—problems which could not be solved mathematically. The optical method, however, dealt with the torsion problem, whereas engineers generally looked upon stresses and strains as partly direct, partly bending, and partly torsional, regarding bending and torsion as the most important. Now, however, there was a method of determining, with fair accuracy, the torsional stresses produced by a torque; therefore, there were two methods of solving certain questions that needed solution. But when the problem involved three dimensions, the methods were inadmissible. Turning to the paper, he also had been troubled about the radius in the corner, and he would ask Mr. Taylor for information as to the length of the legs. He disagreed with the statement in the paper to the effect that the stress fell off so rapidly that its maximum value was to all intents and purposes a matter of no importance if the material was capable of yielding. He would regard that as true if the material were subjected to a stress in one direction only, but not otherwise. With regard to the author's list of theorems, the theorem marked (*a*) did not appear to the speaker to be a question of stress distribution at all; it was simply a statement that with a torque or bending moment the axis could be moved to any desired point in the plane, keeping it parallel to itself. In (*b*) it was stated that "any addition of material to a section must increase the torque." Again, he could not agree that this was true if a re-entrant angle were put in the additional material. If, for instance, a strip with a gap in it were placed round a circular section, there would then be a sharp re-entrant angle. Paragraph (*c*) contained the statement that if a concave part of the boundary approximated to a sharp corner, the stress at that point might be very high. That, of course, was so, and therefore in the former case the addition of material weakened the shape. In many cases a structure could be strengthened by the removal of material, and Emerson's paradox was perhaps the simplest case. If a beam of triangular section were loaded so that the base was horizontal and the apex downwards, and then about one-sixth from the vertex planed off, there would be less stress on the beam under the same loading. He thought the formula "$C = \frac{1}{2} AK^2$" might confuse some people if AK^2 were a well known expression.

Mr. Taylor then replied to the discussion. In answer to the president's question, relative to the non-uniformity of thickness in the film, he would say that Professor Boys had stated that the surface tension—which was the point of importance—was uniform even although the thickness of the film might vary by one thousand times. This the speaker illustrated by imagining a film in a vertical plane, and attached to a frame at the top and at the two vertical edges. The lower edge was connected to a loose bar of some weight. In consequence of the liquid being drawn down to the bottom the film was enormously thicker there than that at the top. The film at the top was so thin that it would not then reflect any light and became black. Although this film was thinner by almost one thousand times at the top than at the bottom, the tension, nevertheless, must be the same because the weight of the film was supported along the whole length of the film. In relation to Mr. Fowler's remarks, the speaker regarded himself as fortunate in finding someone willing to entertain his theories. He agreed that Table 4, upon which Professor Gibson had commented, was a little misleading. The case of the L-shaped bar was considered as twisted through a given angle, and not a given torque. Professor Gibson was quite right also in stating that the later figures in the table did not really show that the maximum stress would go up at the corner when twisted with a given torque at a given moment. He (the speaker) thought it would be of interest to work out a case in which there was a given torque; but then the length of the arm would have to be considered. In reply to Mr. Guest, he might here say that the length of the arms was, to all intents and purposes, infinite. It was impossible to have an infinite hole, but the desired effect was obtained by the placing of a normal septum on each of the arms. Reverting to other questions by Professor Gibson, he would leave the answers to Mr. Griffith, as the latter had carried out the work in connection with the empirical formulæ. He was interested in learning, from Mr. Bairstow that Marcel Brillouin had made calculations for unsymmetrical sections, but, of course, only certain unsymmetrical sections had been dealt with. He did not suppose Mr. Bairstow to mean that M. Brillouin could calculate any unsymmetrical section, unless with very great difficulty.

In investigating the twisting of hollow bars, the torsioning in such cases could not be accomplished by the method set forth in the paper; the problem had been solved, but not directly. In order to solve the hollow section problem by the method put forward, it would be necessary to cut a hole in a plate to the shape of the outer boundary of the section, and another, in another plate, to the shape of the inner boundary. These were in parallel planes, but not in the same plane, and a method was devised of finding how high the plate which represented the hollow had to be raised above the plane of the boundary. The question was one of the many that the authors would deal with at some future time. Dealing with Mr. Guest's observations, he had already explained the case of the arms in the L-shaped beam. He was glad to hear about the effect of the metal giving. As to the applicability of St. Venant's equations to the actual twisting of materials, this question was outside the scope of the paper, but he might observe that Mr. Griffith had done a good deal of work in that direction. Turning to theorem (*b*), quoted by Mr. Guest, he could not quite understand the objection raised. It was not stated in the paper that the addition of material to a section increased its strength; what was said was this, that it increased the torque, which, of course, would give greater stiffness. As Mr. Guest had said, by putting a ring round the section, with a gap in it, the maximum stress would be increased.

The president then proposed a hearty vote of thanks to the authors remarking, as Dr. Hele-Shaw had done, that it was a great compliment to have had such a paper presented to the Institution. Finally he announced that the next general meeting would take place on January 18, 1918, when two papers would be read, namely, one the "Utility of Motor Tractors for Tillage," by Mr. A. Amos, and the other on "Tractors on Bad Roads or Land," by Mr. L. A. Legros.

THE USE OF SOAP FILMS IN SOLVING TORSION PROBLEMS.*

By A. A. Griffith, M.Eng., of S. Farnborough, and G. I. Taylor, M.A., of London.

Introduction.—The equations which represent the torsion of an elastic bar of any uniform cross-section are of exactly the same form as those which represent the displacement of a soap film, due to a slight pressure acting on its surface, the film being stretched over a hole in a flat plate, of the same shape as the cross-section of the bar. The theory of this relationship is briefly outlined, and it is shown that advantage may be taken of the analogy to find the stresses and torsional stiffness of a twisted bar or shaft of any cross-section whatever, by making appropriate measurements of soap films. The method is technically useful because there is no restriction on the shape of sections with which it is capable of dealing, whereas the number of cases in which the equations can be solved analytically is extremely limited.

The apparatus used for measuring films is described and illustrated, and examples of its use are given. These include simple geometrical figures, for which the results of the soap-film method may be checked by calculation, and also two instances of technically important sections which are not amenable to mathematical treatment. In the first of these, the magnitude of the stress in an internal corner, and its dependence on the radius of the fillet, are investigated, while in the second the stresses and torque of a twisted aeroplane wing spar, of I-section, are discussed, and comparisons between the results of the method and those of some direct torsion experiments are given.

Finally, a number of general theorems relating to, and approximate formulæ for, the stiffness and strengths of shafts and beams, are obtained with the help of the soap-film analogy. It is shown by comparison with other results, that it is possible to deduce thus, in nearly every case, figures for those torsional data usually required in practice, which are within a few per cent. of the exact values. The superiority of these formulæ over those now in use appears to be due to the introduction, it is believed for the first time, of the length of the perimeter of the cross-section as a factor. This was suggested almost immediately by the soap-film analogy, and is an instance of the value of the latter as a means of forming a clear idea of the nature of the torsion problem.

General Considerations.—In the old theory of the torsion of shafts or beams of uniform cross-section, which was originated by Coulomb, it was assumed that sections of the bar, initially plane and at right angles to the axis of torsion, remained so when the bar was twisted, and that the only strains set up were those due to the relative rotation of adjacent sections about the axis.

In his classical memoir on the mathematical theory of torsion, Saint-Venant showed that the assumptions made by Coulomb were valid only in the case of circular shafts, either solid or having concentric circular holes. In every other instance the initially plane section is distorted into a curved surface, and the stresses and strains set up in the bar cannot be calculated until the shape of this curved surface has been found.

A complete discussion of the theory of torsion put forward by Saint-Venant would be out of place in the present paper. It is fully dealt with in books on the mathematical theory of elasticity, among which the treatise of Professor Love† may be mentioned. It is necessary to remark, however, that he showed how to reduce the problem to that of finding a function of the co-ordinates of points on the cross-section, which satisfies a certain partial differential equation. There is, however, no known general analytical method of finding this function for any assigned cross-section, and therefore the torsion problem cannot be solved mathematically for the great majority of technically important sections.

A simple method of determining these stresses would be of the very greatest assistance in general engineering work, and even more so in the many fresh problems which have to be dealt with in aeronautical calculations. In the very complex sections which occur in this work, such as those of airscrew blades, and the many forms of spars and struts, &c., used, it is of the highest importance that correct knowledge should be available, and therefore the authors have carried out work at the

* Paper read before the Institution of Mechanical Engineers on Friday, December 14, 1917.

† A. E. H. Love. "Mathematical Theory of Elasticity," second edition, chap. xiv.

Royal Aircraft Factory, Farnborough, with a view to solving the problem by means of a simple experimental method. The following is a very brief description of the method which has been developed.

A hole is cut, in a thin plate, of the section required to be investigated, and a circular hole of a predetermined diameter is cut alongside it. The plate is placed in a box, and soap films are stretched across the holes. The films are blown out slightly by reducing the air pressure on one side of them. By making suitable measurements of the shape of the resulting film surfaces, as will be explained later, it is possible to find the stresses in a bar of the given section, in terms of the stresses in a circular bar of the same diameter as the circular hole, when the two bars are twisted through the same angle per unit length. It is equally easy, by means of other measurements, to find the ratio of the torques which must be applied to the two bars, in order to produce the same twist in each. It will readily be seen that by this means the most complicated sections can be dealt with.

The experimental work is described in the body of the paper, while the mathematical theory of the method is discussed in an appendix.

Experimental Methods.—It is seen from the mathematical discussion given in the appendix that, in order that full advantage may be taken of the information on torsion which soap films are capable of furnishing, apparatus is required with which three kinds of measurements can be made, namely :—

(A) Measurements of the inclination of the film to the plane of the plate at any point, for the determination of stresses.

(B) Determination of the contour lines of the film.

(C) Comparison of the displaced volumes of the test film and circular standard for finding the corresponding torque ratio.

The available means of measurement will now be enumerated under these three heads.

(A) For this purpose optical reflection methods naturally suggest themselves. In the apparatus used by the authors, the image of an electric lamp filament is viewed in the film in such a way that the reflected ray is coincident with the incident one, so that their common direction gives the inclination of the normal to the surface of the film. This experiment may conveniently be referred to as the measurement of angles by auto-collimation.

(B) For mapping contour lines, a steel needle point, moistened with soap solution, is arranged to move about over the plate carrying the film, its distance therefrom being adjustable by means of a micrometer screw. The point is made to approach the film till the distortion of the image in the latter shows that contact has occurred. This position is remarkably definite, so much so, indeed, that it is possible, with ordinary care, to limit the error in the measurement of the normal co-ordinate to ± 0.001 in. This method of mapping contours will be referred to as the "spherometer" method. Another method, which was suggested to the authors by Mr. Vernon Boys, F.R.S., though not so convenient as the one already described, is, nevertheless, useful in affording a ready means of exhibiting the shape of the contour lines to the eye. If a film be left undisturbed for, say, 15 minutes, owing to drainage and consequent thinning of the film, a black spot appears at the highest point and gradually increases in size till, after the lapse of several hours, it may include the whole surface of the film. Its edge is quite sharply defined and is horizontal. Hence, if the plate has been levelled up beforehand, the edge of the black spot coincides at any moment with a contour line of the film.

(C) The most obvious way of measuring the displaced volume of the films is to blow them up by running a known volume of water, or, preferably, soap solution, into the apparatus from a pipette or burette. The volume of the circular film may be calculated from the observed value of the inclination at its boundary, since its surface is a portion of a sphere, and hence the volume of the other film may be obtained by difference. The most accurate results are obtained by giving the film a slight initial displacement before running in the known volume of liquid, and measuring the difference of the inclinations at the boundary of the circular film.

Another method, which requires a certain amount of practice, but which has the advantage of great simplicity, is to blow up the two films, observe the angle at the edge of the circular one, and then carefully place a flat plate, moistened with soap solution, on the test film, so as to cover it completely, until the flat plate is in contact with the test plate. The total volume is then contained in the circular film, and it can be determined in the ordinary way by again observing the inclination. Hence the volume of the test film may be found.

Description of Apparatus.—In the apparatus used by the authors, the films are formed on holes cut to the required shapes in flat aluminium plates, of No. 18 S.W.G. thickness. The plates are held in a horizontal position during the experiment, and the edges of the holes are chamfered off on the under side, to an angle of about 45 deg., in order to fix the plane of the boundary. The soap solution used is that recommended by Mr. Boys, namely, pure sodium or potassium oleate, glycerine and distilled water. It may be obtained ready for use from Messrs. Griffin, Kingsway, London.

The photograph above shows the apparatus in which the films are formed, and also illustrates the construction of the spherometer. The test plate is clamped between the two halves of the cast-iron box A. The lower part of this box takes the form of a shallow tray ¼ in. deep, blackened inside and supported on levelling screws, while the upper portion is simply a square frame carrying the clamping studs and enamelled white inside. A three-way cock communicates with the former and a plain tube with the latter. The film shown in the photograph represents a section of an airscrew blade. It will be noticed that a black spot has commenced to form at the top of the bubble.

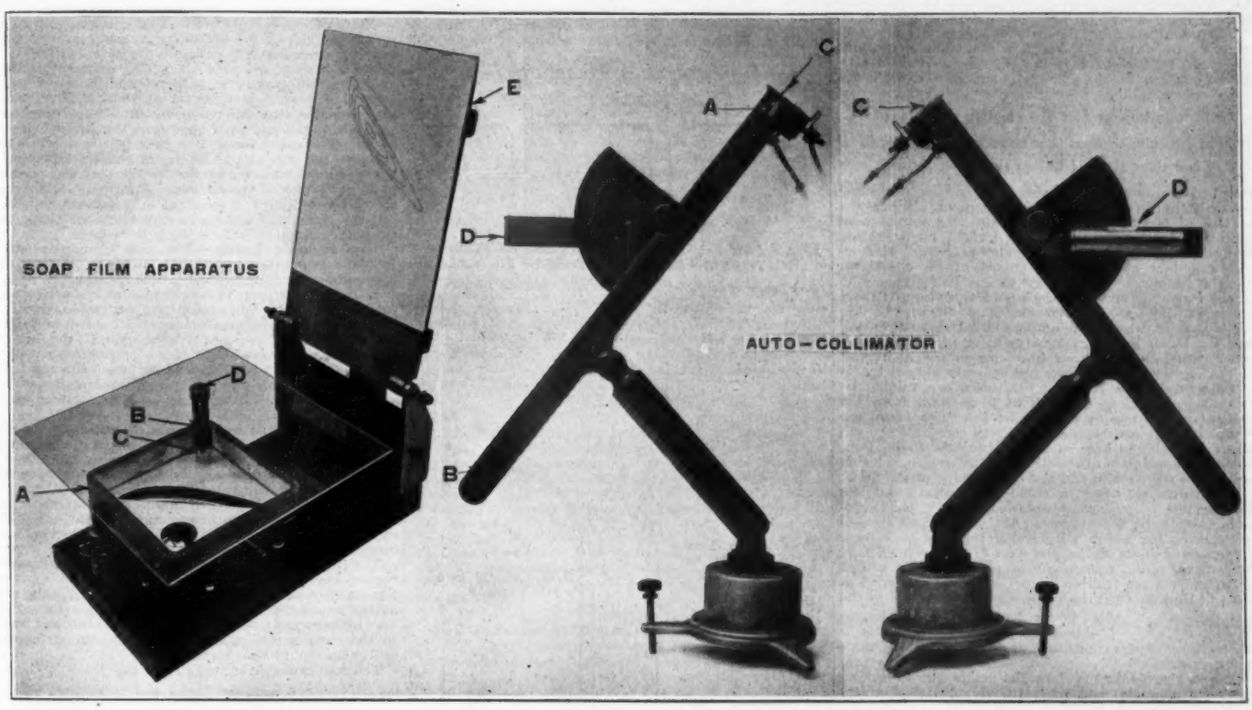
The spherometer apparatus consists of a screw B, of 1 mm. pitch passing through a hole in a sheet of plate glass, ¼ in. thick, and sufficiently large to cover the box in any possible position. It slides about on the flat upper face of the latter. The lower end of the screw carries a hard steel point C, tapering about 1 in 4, and its divided head moves beside a fixed vertical scale. Fixed above the screw and in its centre line is the steel recording point D. The record is made on a sheet of paper fixed to the board E, which can swing about a horizontal axis at the same height as D. To mark any position of the screw, it is merely necessary to prick a dot on the paper by bringing it down on the recording point.

In the auto-collimator light from the straight filament of the 2-volt bulb A is reflected from the surface of the film through a V-nick B and a pin-hole eyepiece C, placed close to the lamp and shaded from direct light by a small screen. The inclinometer D, which measures the angle which the optical axis makes with the vertical, consists of a spirit level, of 6 ft. radius, fixed to an arm which moves over a quadrant graduated in degrees. The apparatus is mounted, by means of a stiff-jointed link, on a tripod stand weighted with lead. Fine adjustment of angle is made with a screw.

Method of using Apparatus.—In using the soap-film apparatus, the test plate and lower half of the test-box, which must both be perfectly clean, are moistened with soap solution and clamped together by means of the upper frame. The soap solution not only forms an airtight joint between the plate and box, but also serves to saturate the air within the apparatus, so that evaporation from the surface of the film is minimised. The edges of the holes are now tested with the spherometer point: if they are not parallel to the plane of motion of the glass plate they must be adjusted. A film is then drawn across the holes by means of a strip of celluloid wetted with soap solution fresh from the stock bottle and the glass cover immediately replaced. The blowing up should be done by suction from the tube in the upper frame, and not by blowing through the stop-cock, as the carbon dioxide introduced by the latter method might affect the life of the film adversely. Measurements may now be made as desired. It should be remembered that if the auto-collimator is used, the apparatus must be levelled up beforehand.

In the case of the spherometer, the point, previously moistened with fresh solution, is set to a given height and made to touch the film at a number of positions, which are marked on the paper. This is repeated for as many contour lines as may be required. The plate need not be levelled. A contour map taken in this way is to be seen on the board.

Usually, the use of the auto-collimator is confined to the determination of inclinations at given points on the boundary, which are marked by scratches on the plate. It is better for stress measurements than the contour line method, since it gives the inclination directly, whereas in the other case the latter can only be found by a graphical differentiation. The use of the optical method may be extended to the finding of inclinations at points other than those on the boundary, with the help of the spherometer, in the following manner. The outline of the experimental hole is marked on the paper by means of the recording point, and the position of the point for which the stress is desired is added. The glass plate is adjusted until the



APPARATUS FOR MEASURING AND RECORDING THE CONTOUR LINES AND INCLINATIONS OF SOAP FILMS.

recording point coincides with it. The needle is screwed down till it just touches the film, and its height is noted. It is then screwed back till the film breaks away, and finally brought down again to within one or two thousandths of an inch of its former height. The auto-collimator is now adjusted till the image of the filament is seen in the film just below the needle-point. The reading of the inclinometer then gives the required angle.

Accuracy of Results.—Strictly speaking, the soap-film surface can only be taken to represent the torsion function if its inclination γ is everywhere so small that $\sin\gamma = \tan\gamma$ to the required order of accuracy. This would mean, however, that the quantities measured would be so small as to render excessive experimental errors unavoidable. A compromise must therefore be effected. In point of fact, it has been found from experiments on sections for which the torsion function can be calculated, that the ratio of the stress at a point in any section to the stress at a point in a circular shaft, whose radius equals the value of $\frac{2A}{P}$ for the section, is given quite satisfactorily by the value of $\frac{\sin\gamma}{\sin\mu}$ where γ and μ are the respective inclinations of the corresponding films, even when γ is as much as 35 deg. Similarly, the volume ratio of the films has been found to be a sufficiently good approximation to the corresponding torque ratio, for a like amount of displacement.

In contour mapping, the greatest accuracy is obtained, with the apparatus at present in use, when μ is about 20 deg. That is to say, the displacement should be rather less than for the other two methods of experiment.

In all soap-film measurements the experimental error is naturally greater the smaller the value of $\frac{2A}{P}$. Reliable results cannot be obtained, in general, if $\frac{2A}{P}$ is less than about $\frac{1}{4}$ in., so that a shape such as a rolled I-beam section could not be treated satisfactorily in an apparatus of convenient size. As a matter of fact, however, the shape of a symmetrical soap film is unaltered if it be divided by a septum or flat plate which passes through an axis of symmetry and is normal to the plane of the boundary. It is therefore only necessary to cut half the section in the test plate and to place a normal septum of sheet metal at the line of division. This device, for the suggestion of which the authors are indebted to the late Dr. C. V. Burton, may also be employed in many other cases where contour lines are so nearly normal to the septum that they are not sensibly altered by its introduction. An I-beam, for instance, might be treated by dividing the web at a distance from the flange equal to two or three times the thickness of the web. It has been found advisable to carry the septum down through the hole so that it projects about $\frac{1}{4}$ in. below the underside of the plate, as, otherwise, solution collects in the corners and spoils the shape of the film.

The values set down in Table I (annexed), indicate the degree of accuracy obtainable with the auto-collimator in the determination of the maximum stresses in sections for which the torsion function is known. They also give an idea of the sizes of holes which have been found most convenient in practice. The angles given are (α) the maximum inclination at the edge of the test film, and (β) the inclination at the edge of the circular film of radius $\frac{2A}{P}$. They are usually the means of about five observations, and are expressed in decimals of a degree.

The last two columns show the errors due to taking the ratio of angles and the ratio of sines respectively as giving the stress ratio.

The error is always positive for α/β, and its mean value is 1.98 per cent. In the case of $\frac{\sin\alpha}{\sin\beta}$ the average error is only 0.62 per cent. In only two instances does the error reach 1 per cent., and in both it is negative. The presence of sharp corners seems to introduce a negative error which is naturally greatest when the corners are nearest to the observation point. Otherwise, there is no evidence that the error depends to any great extent on the shape. Nos. 4, 5, 7 and 8 in the table are examples of the application of the method of normal septa.

Table II, below, shows the results of volume determinations made on each of the sections 1 to 8 given in the previous table.

Table II.—*Showing Experimental Error in Determining Torques by Means of Soap Films.*

No.	Section.	Maximum Inclination.	Observed Volume Ratio.	Calculated Torque Ratio.	Error
		deg.			p.c.
1	Equilateral triangle: Height, 3 in. ..	32.06	1.953	1.985	−1.6
2	Square: Side, 3 in. ..	30.39	1.416	1.432	−1.1
3	Ellipse: Semi-axes, 2 in. × 1 in. ..	30.50	1.143	1.133	+0.9
4	Ellipse: 3 in. × 1 in.	31.01	2.147	2.147	0.0
5	Ellipse: 4 in. × 0.8 in.	36.12	3.041	3.020	+0.7
6	Rectangle: Sides, 4 in. × 2 in.	31.33	1.456	1.475	−1.3
7	Rectangle: 8 in. × 2 in.	35.28	1.749	1.744	+0.3
*8	Infinitely long rectangle	36.00	0.858	0.848	+1.2

* On 4-in. length.

Table I.—Showing Experimental Error in Determining Stress by Means of Soap Films.

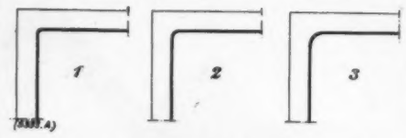
	Section.	Radius of Circle.	α.	β.	$\frac{\alpha}{\beta}$	$\frac{\sin\alpha}{\sin\beta}$	True Value.	Error $\frac{\alpha}{\beta}$	Error $\frac{\sin\alpha}{\sin\beta}$
		in.	deg.	deg.				per cent.	per cent.
1	Equilateral triangle: Height, 3 in.	1.00	32.65	21.19	1.536	1.490	1.500	+2.4	−0.7
2	Square: Side, 3 in.	1.5	29.11	21.34	1.364	1.337	1.350	+1.0	−1.0
3	Ellipse: Semi-axes 2 in. × 1 in. ..	1.296	30.71	24.32	1.263	1.240	1.234	+2.4	+0.5
4	Ellipse: 3 in. × 1 in.	1.410	31.10	24.00	1.296	1.270	1.276	+1.6	−0.5
5	Ellipse: 4 in. × 0.8 in.	1.196	35.35	26.58	1.331	1.293	1.286	+3.5	+0.5
6	Rectangle: 4 in. × 2 in	1.333	31.70	22.36	1.418	1.380	1.395	+1.6	−1.1
7	Rectangle: 8 in. × 2 in.	1.60	34.83	27.23	1.279	1.247	1.245	+2.7	+0.2
*8	Infinitely long rectangle: 1 in. wide	1.00	36.42	36.19	1.006	1.005	1.000	+0.6	+0.5

* On 4-in. length.

The average error is 0.89 per cent. In four of the eight cases considered the error is greater than 1 per cent., and in three of these it is negative. One may conclude that the probable error is somewhat greater than it is for the stress measurements, and that it tends to be negative. Its upper limit is probably not much in excess of 2 per cent. The remarks already made regarding the dependence of accuracy on the shape of the section apply equally to torque measurements.

As additional confirmation of the correctness of solutions of the torsion problem obtained by the soap film method, some experiments on wooden beams may

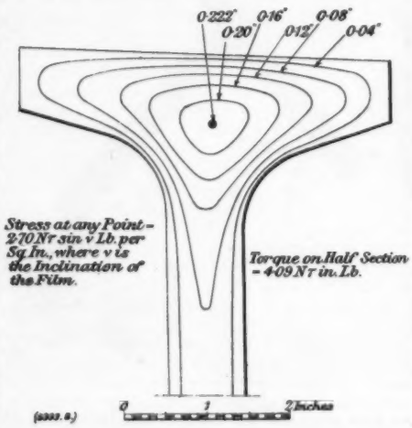
Fig. 1. STRESS IN INTERNAL CORNER



(3997.A)

Fig. 2. LINES OF SHEARING STRESS IN THE TORSION OF A WOODEN SPAR TO SCALE.

The Figures give the Heights of the Contour-Lines of the corresponding Soap Film



(3997.B)

be cited. In the first of these, a walnut plank was shaped so that its section was exactly the same as the hole in one of the test plates, which represented a section of an airscrew blade, of fineness ratio 10.55, having its thickest part about a third of the way from the leading edge. The value of the modulus of rigidity N was found by performing a torsion test on this plank, using the expression for the torque given by a soap-film experiment on the plate which was used in shaping the plank. N was found to be 0.1355×10^6 lb. per square inch. Five circular rods were then cut from the plank and their rigidities were measured. The mean value of N found in this way was 0.1387×10^6, a difference of only 2.3 per cent.

Similar experiments were made on three lengths of spruce wing-spar, of I-section. The results are set down below. Column A shows the value of N, obtained by twisting the spar, using the figure for torque obtained

Table III.—*Comparison of Soap Film Results with those of Direct Torsion Experiments.*

Spar No.	A. Lb. per Square Inch × 10^6.	B. Lb. per Square Inch × 10^6.	C. Lb. per Square Inch × 10^6.	D.
				per cent.
1	0.1091	0.1172	0.1063	2.5
2	0.0873	0.0640	0.0966	8.7
3	0.1156	0.1200	0.1151	1.7

by soap films. Columns B and C show the values of N found from round specimens cut from the thickest part of the two flanges, while column D gives the percentage difference between A and the mean of B and C.

The comparatively large discrepancy in No. 2 is probably due to the extraordinarily large variation of N over this particular spar.

When contour lines have been mapped the torque may be found from them by integration. If the graphical work is carefully done the value found in this way is rather more accurate than the one obtained by the volumetric method. Contours may also be used to find stresses by differentiation, that is, by measuring the distance apart of the neighbouring contour lines; but here the comparison is decidedly in favour of the direct process, owing to the difficulties inseparable from graphical differentiation. The contour map is, nevertheless, a very useful means of showing the general nature of the stress distribution throughout the section in a clear and compact manner. The highly stressed parts show many lines bunched together, while few traverse the regions of low stress, and the direction of the resultant stress is shown by that of the contours at every point of the section. Furthermore, the map solves the torsion problem, not only for the boundary, but also for every section having the same shape as a contour line.

Experimental Results.—The two examples which follow serve to illustrate the use of the soap-film apparatus in solving typical problems in design;—

1. It is well known that the stress at a sharp internal corner of a twisted bar is infinite or, rather, would be infinite if the elastic equations did not cease to hold when the stress becomes very high. If the internal corner is rounded off the stress is reduced: but so far no method has been devised by which the amount of reduction in strain due to a given amount of rounding can be estimated. This problem has been solved by the use of soap films.

An L-shaped hole was cut in a plate. Its arms were 5 in. long by 1 in. wide, and small pieces of sheet metal were fixed at each end perpendicular to the shape of the hole, so as to form normal septa. The section was then practically equivalent to an angle with arms of infinite length. The radius in the internal corner was enlarged step by step, observations of the maximum inclination at the internal corner being taken on each occasion.

The inclination of the film at a point 3.5 in. from the corner was also observed, and was taken to represent the mean boundary stress in the arm, which is the same as the boundary stress at a point far from the corner. The ratio of the maximum stress at the internal corner to the mean stress in the arm was tabulated for each radius on the internal corner.

The results are given in Table IV:—

Table IV.—*Showing the Effect of Rounding the Internal Corner on the Strength of a Twisted L-shaped Angle Beam.*

Radius of Internal Corner.	Ratio: Maximum Stress / Stress in Arm
In.	
0.10	1.890
0.20	1.540
0.30	1.480
0.40	1.445
0.50	1.430
0.60	1.420
0.70	1.415
0.80	1.416
1.00	1.422
1.50	1.500
2.00	1.660

It will be seen that the maximum stress in the internal corner does not begin to increase to any great extent till the radius of the corner becomes less than one-fifth of the thickness of the arms. A curious point which will be noticed in connection with the table is the minimum value of the ratio of the maximum stress to the stress in the arm which occurs when the radius of the corner is about 0.7 of the thickness of the arm.

In Fig. 1 is shown a diagram representing the appearance of these sections of angle-irons.

No. 1 is the angle-iron for which the radius of the corner is one-tenth of the thickness of the arm. This angle is distinctly weak at the corner.

In No. 2 the radius is one-fifth of the thickness. This angle-iron is nearly as strong as it can be. Very little increase in strength is effected by rounding off the corner more than this. No. 3 is the angle with minimum ratio of stress in corner to stress in arm.

A further experiment was made to determine the extent of the region of high stress in angle-iron No. 1. For this purpose contour lines were mapped, and from these the slope of the bubble was found at a number of points on the line of symmetry of the angle-iron. Hence the stresses at these points were deduced. The results are given in the following table.

TABLE V.—*Showing the Rate of Falling-off of the Stress in the Internal Corner of the Angle-Iron.*

Distance from Boundary. In.	Ratio of Stress at Points to Mean Boundary Stress in the Arm.
0.00	1.89
0.05	1.36
0.10	1.12
0.20	0.77
0.30	0.49
0.40	0.24
0.50	0.00

It will be seen that the stress falls off so rapidly that its maximum value is to all intents and purposes a matter of no importance, if the material is capable of yielding. If the material is brittle and not ductile a crack would, of course, start at the point of maximum stress and penetrate the section.

(2) The diagram shown in Fig. 2, which represents the half section of a wooden wing spar, is a good example of the contour line method. The close grouping of the lines near the internal radii, denoting high stress, is immediately evident. The projecting parts of the flange are lightly stressed and contribute little to the torsional stiffness. The stress at the middle of the upper face is, however, considerable, being in fact next in order of magnitude below that in the radii. The stress near the middle of the web is practically constant and equal to that in a very long rectangular section of the same thickness under the same twist.

A further point of interest is that the "unstressed fibre" is very near the centre of the largest circle which can be inscribed in the section. It will also be observed that the three points of greatest stress are almost coincident with the points of contact of the circle. The maximum stress is about 1.89 times the mean boundary stress.

The figures given below the diagram for the values of the stress and torque on the section fully confirm the generally accepted notions regarding the extreme weakness of I-beams in torsion.

General Deductions from the Soap-Film Analogy.—One of the greatest advantages of considering the torsion problem from the soap-film standpoint arises from the circumstance that it is very much easier to form a mental picture of a soap bubble than it is to visualise the complicated system of shear-strains in a twisted bar. It cannot be too strongly urged that the surest way of forming a clear idea of the nature of the torsion problem is to blow a few soap films on boundaries of various shapes. This can be done with the simplest of apparatus The holes may be cut in plates of thin sheet metal, which can be luted on to the top of a biscuit tin with vaseline or soft soap. To blow the films up it is only necessary to bore a hole in the bottom of the tin and stand it in a vessel containing water. Two sections may readily be compared by cutting them in the same plate. A simple way of estimating inclinations is to view the image of the eye in the film and adjust the arm of a clinograph so that it lies along the line of sight. Black spots, as previously mentioned, may be observed if arrangements are made to cover the films with a sheet of glass, in order to exclude dust and air currents.

With the aid of simple apparatus of this kind the truth of theorems, such as those contained in the following list, may be readily demonstrated.

(*a*) The stress distribution (and therefore the torque) for any section is independent of the axis of twist. This is easily seen, since the shape of the soap film is completely determined by the boundary and the value of $\frac{4S}{p}$. Hence the torque on a number of bars clamped together at their ends may be found by adding the separate torques which would be necessary to twist each through the same angle. This, as in other cases, applies to torque only. It will be realised that in practice there will be bending stresses which must be taken account of in the usual way.

(*b*) Any addition of material to a section must increase the torque, and *vice versa*, so long as the distribution of material in the original section is unaltered.

(*c*) Any cut made in a section, whether it decreases the area or not, must decrease the torque.

(*d*) The stress at any point of the boundary of a section is never less than the boundary stress in a circular bar under the same twist, whose radius is equal to that of the circle inscribed in the section, which touches the boundary at the point in question.

More generally, if one section lie entirely inside another, so as to touch it at two or more points, the stresses in the inner figure are less than those in the outer one at the points of contact: if the two figures are approximately congruent in the neighbourhood of the points of contact, the difference between the stresses is small. The maximum stress in a section is not greater than $2\alpha N\tau$, where α is the radius of the largest inscribed circle, unless the boundary is concave, that is, re-entrant.

(*e*) If a concave part of the boundary approximates to a sharp corner, the stress at this point may be very high, and if the curvature is infinite then the stress is also theoretically infinite, whatever be the situation of the corner with respect to the rest of the section. Actually, of course, if the material is ductile, we can only deduce that the stresses at such a corner are above the elastic limit.

(*f*) It is a consequence of (*e*) that it does not necessarily follow that the making of a cut in a section will reduce its strength, whether material is removed or not. As an example of this, one may quote the case of an angle iron in which the internal corner is quite sharp. It is well known in practice that this will often fracture. It may be strengthened, however, by reducing the section, planing out a semicircular groove at the root of the angle iron.

(*g*) There can be no discontinuous changes of stress anywhere in a section, excepting only those parts of the boundary where the curvature is infinite (concave or convex sharp corners).

(*h*) The maximum stress occurs at or near one of the points of contact of the largest inscribed circle, and not, in general, at the point of the boundary nearest the centroid, as has been hitherto assumed. An exception may occur if, at some other part of the boundary, the curvature is (algebraically) considerably less (that is, the boundary is more concave) than it is at this point.

(*i*) If a section which is long compared with its greatest thickness be bent so that its area and the length of its median line are unchanged, its torque will not be greatly changed thereby. For instance, the torsional stiffness of a metal plate is practically unaltered by folding or rolling it up into the form of an L or a split tube. Soap-film experiments show, in fact, that there is a diminution of less than 5 per cent. when the inner radius of the boundary is not less than the thickness at the bend.

(*j*) The "unstressed fibre," which is situated at the point corresponding with the maximum ordinate of the soap film, is near the centre of the largest circle which can be inscribed in the section.

In general, the inscribed circle has a maximum value wherever it touches the boundary at more than two points, and there is usually an unstressed fibre near the centre of each of these circles. Between each pair of maximum ordinates on the soap film, however, there is a "minimax" point, which is near the centre of the corresponding minimum inscribed circle. This fibre in the bar is also unstressed.

(*k*) The "lines of shearing stress" round the unstressed fibres of the first sort are initially ellipses, and round those of the second sort hyperbolæ, from which shapes they gradually approximate to that of the boundary. Notions of this sort are useful in practice, because it is possible, with their help, to sketch in the general nature of the lines of shearing stress for any section.

(To be continued.) b 699

SOCIETE JOHN COCKERILL, SERAING–LIEGE.—This company has issued its report for the last financial year, ending June 30: it pictures the lamentable state of the Belgian industry. The general position, says the report, has again become worse during the last year. Business has completely stopped at the company's works, and the arrangements which had been started at the beginning of the war for supplying employment to the operatives had come to an end, owing to fresh regulations having been issued by the German authorities.

THE NON-FERROUS METALS BILL.—The Council of the Institution of Electrical Engineers has passed the following resolution, which has been transmitted to Sir Albert Stanley:—"That the Council of the Institution of Electrical Engineers welcomes the Non-ferrous Metals Bill, approves its principles and congratulates the President of the Board of Trade on its introduction. The council, representing an Institution whose members are interested so widely in the supply of non-ferrous metals, unanimously supports this measure designed to keep the control of the supply of these essential metals in British hands."

THE GOVERNMENT TRADE AND COMMERCE DEPARTMENT.—We are officially informed that the new joint department of the Board of Trade and the Foreign Office, whose formation was announced in the recent White Paper on the Future Organisation of Commercial Intelligence, has now been constituted. We gave full particulars regarding the new department in a note on page 638 ante. It will be known as the Department of Overseas Trade (Development and Intelligence). It will be represented in Parliament by Sir Arthur Steel-Maitland, M.P., who will occupy the position both of Additional Under-Secretary of State for Foreign Affairs and also of Additional Parliamentary Secretary at the Board of Trade. The department will comprise the existing Department of Commercial Intelligence of the Board of Trade, including the management of the British Industries Fairs: the War Trade Intelligence Department: the section of the Foreign Trade Department of the Foreign Office dealing with Form K and with other matters relating to the promotion of trade abroad: and certain functions now performed at the Foreign Office in connection with commercial intelligence and with the Commercial Attache and Consular Services. Sir William Clark, K.C.S.I., C.M.G., has been appointed Comptroller-General of the new department, and Mr. F. G. A. Butler, C.B., C.M.G., formerly of the Colonial Office, has been appointed Director of the Overseas Division. An advisory committee of business men to the new department is in process of formation and will be announced shortly. The temporary headquarters of the department will be at 73, Basinghall Street, E.C. 2, to which personal letters for Sir Arthur Steel-Maitland should be addressed. The commercial intelligence staff will for the present continue to be housed at the same address. The office at Basinghall Street contains an enquiry bureau where information on all matters affecting trade can be obtained on personal application: or enquiries can be addressed there either by post or telephone (telephone Nos.: London Wall 4713 and 4717). The war trade intelligence staff will remain in their existing offices in Lake Buildings, London, S.W.1. Attention is called to the fact (as regards which some misconception has prevailed) that the whole of the rest of the Foreign Trade Department will remain as heretofore under the controllership of Sir Ernest Pollock K.B.E., K.C., M.P., at Lancaster House.

ELECTRICAL MACHINERY IN BRITISH MALAYA.

A SECTION of the annual report of the Senior Warden of Mines in the Federated Malay States is devoted to the inspection of electrical plant in use in the country. From the last report by Mr. W. Eyre Kenny, M.Inst.C.E., it appears that in the Federated Malay States alone there were 80 installations of generating plant in 1916, of which 50 were in the State of Perak and 22 in Selangor. The employment was as follows, in kilowatts: Mining, 7,918; agricultural, 200; general, 228; government, 10. In kilowatts, it was allocated as follows: Power, 7,936; lighting, 2,865—giving a generating aggregate of 10,801 kw., Government plant being responsible for most of the lighting. The above figures refer only to generating plant driven by prime movers. There is, in addition, motor-generating plant in use of about 400 kw. capacity. The horse-power of motors employed aggregates about 10,250, the increase from the previous year's figure of 9,000 being due mainly to the inclusion of last year's return of auxiliary and converting plant in Kuala Lumpur Electric Light Station. Mr. Eyre Kenny reports that the larger power plants, which are perforce controlled by first or second-grade electrical engineers, are, as a rule, kept in good condition; smaller mine-lighting plants, which are generally controlled by native chargemen supervised by Europeans, who have little or no electrical knowledge, are not so satisfactory.

The statistics of the Imports and Exports Department of the Straits Settlements show that the United Kingdom supplies most of the electrical machinery and accessories in use in British Malaya. For four years the total value of imports and exports was as follows:—

	Imports. £	Exports. £
1913	73,978	8,824
1914	50,898	13,046
1915	39,690	23,705
1916	44,203	21,336

An interesting comparison is obtained by analysing the principal sources of these supplies. The United Kingdom's share of the 1914 imports amounted to 39,408*l.*, Germany's to 4,310*l.*, and the United States' to 2,075*l.* The statistics for 1913 are compared below with two war years:—

——	1913.	1915.	1916.
	£	£	£
United Kingdom	58,415	30,795	33,450
Germany	9,474	221	—
Denmark	973	415	883
Japan	827	931	1,784
United States	787	1,588	2,310
Italy	649	884	1,040
Sweden	427	—	—
Austria-Hungary	160	—	—
Netherlands	134	1,094	580
Hong Kong	—	—	1,198
China	—	—	732

The only figures calling for special mention in the above table are those of the Netherlands, which suggest that possibly German exports found a way out through Dutch ports. It is easy to understand how the United States and Japan have been able to expand their markets in the Far East during the present upheaval in Europe; but the statistics for Hong Kong and China are less easy to explain, unless it be that the pushing engineering firms of Hong Kong and Shanghai have carried their enterprise into new fields of manufacture. More likely this is a transit trade of which the original port of shipment is lost for statistical purposes.

To anyone unacquainted with the trade of the Straits Settlements ports, the proportion of exports may appear high. As a matter of fact, only a small proportion of the exports leave the Malay Peninsula for Siam and the Dutch Indies, most of the goods being exported by rail to the hinterland provided by the Federated Malay States, which took 6,195*l.* in 1913, 19,921*l.* in 1915 and 13,871*l.* in 1916. In the latter year, the un-Federated Malay States took electrical machinery and accessories valued at 3,470*l.*, and as the Malay Peninsula is being rapidly opened up by railway and road communication there should be a growing demand for machinery of all sorts in this region after the war.

THE NOBEL BROTHERS NAPHTHA PRODUCTION COMPANY, ST. PETERSBURG. This concern has earned net profits for the last financial year amounting to 49,750,000 roubles, writings-off amounting in the aggregate to 43,300,000 roubles, having been provided for. The dividend for the year was fixed at 40 per cent., against 30 per cent. for the previous year, the new shares only receiving a half dividend. Real property and installations stand booked at 34,560,000 roubles. Liabilities amount to 100,160,000 roubles, but, on the other side, cash in hand, bank credits and holdings of stock are represented by 129,700,000 roubles: outstanding accounts by 85,770,000 roubles: materials by 15,160,000 roubles: stocks by 42,660,000 roubles. The share capital is 45,000,000 roubles, the reserve fund amounts to 15,000,000 roubles, the special reserve fund to 42,670,000 roubles and the works consolidated fund to 15,640,000 roubles. The prospects for the current year are fairly satisfactory, as the prices for auxiliary naphtha products have risen very materially.

INDUSTRIAL NOTES.

The Director of the Department of Labour Statistics, in the course of an article in *The Labour Gazette* of December 17, on the Labour Market, states that employment continued good generally in November. The shipbuilding, engineering and metal trades especially were working at high pressure, with much overtime, but in the cotton, woollen and worsted trades employment continued to be affected by the Orders restricting consumption.

The principal changes in rate of wages taking effect in November were war advances of 6*s.* per week to men, 3*s.* per week to women and boys, and 1*s.* 6*d.* per week to girls engaged in the manipulation of railway traffic in Great Britain. Other important increases affected seamen, linen and jute operatives in Scotland, workpeople in general printing offices in London, and employees in the coach-building trade in nearly all the principal centres. Building trade operatives also received advances in many districts.

The number of disputes beginning in November was 72, and the total number of workpeople involved in all disputes in progress was 239,253, as compared with 86,417 in the previous month and 38,647 in November, 1916. The estimated total aggregate duration of all disputes during the month was 997,900 days, as compared with 568,200 days in October, 1917, and 155,000 days in November, 1916.

The average weekly number of vacancies notified to all Employment Exchanges for the four weeks ended November 9, 1917, was 43,284, as compared with 38,097 in the previous five weeks, and with 41,113 in the four weeks ended November 10, 1916. The average weekly number of vacancies filled for the same periods was 32,166, 28,477 and 31,778 respectively.

The general level of retail prices of food in the United Kingdom on the 1st inst. was 105 per cent. above the level of July, 1914, as compared with 106 per cent. a month earlier. By omitting some articles in the dietary, substituting some items for others, and reducing the consumption of fish and sugar to one-half of that prevailing before the war, the general percentage increase since July, 1914, instead of being 105 per cent. would only be 59 per cent.

The Prime Minister received last week, at No. 10, Downing-street, a deputation of the Parliamentary Committee of the Trades Union Congress, when our fiscal policy, the overlapping of Government departments in dealing with labour, and other points were raised.

In the course of his statements to the deputation, the Prime Minister pointed out that one of the greatest difficulties that would face all countries after the war—neutral as well as belligerent—was that of obtaining raw material. At the present moment there was no free movement of goods, so that the question of our future fiscal policy was neither immediate nor urgent. As to the question of overlapping by the different departments of the Government in dealing with Labour, the Prime Minister pointed out that in the past the different Government departments had settled their own disputes and made their own arrangements with Labour. In those days the Government was a comparatively small employer of labour. At the present time, however, with the State by far the largest employer of labour in the country, the position was totally different, and it was expressly in order to meet this new situation that the Ministry of Labour had been set up by the present Administration. He was confident that the matters complained of would be gradually put right.

Considerable progress has been made with the formation of the Local Advisory Committees which are being set up by the Minister of Labour in connection with the Employment Exchanges throughout the country. These committees, which are to consist of representatives nominated by employers and workpeople in the districts served by each Employment Exchange, are to have wide functions in connection with the existing work of the exchanges, and it is proposed that they should play a large part in the work of arranging for the return of sailors and soldiers to civil life after the war. Among the important functions which they will have to discharge immediately is that of ensuring that all possible steps are taken to deal with the finding of employment for the men who are now being discharged from the forces. The exchanges have already placed some 75,000 discharged sailors and soldiers in their first civil employment since leaving the forces. There are to be in all about 250 principal committees. The chairmen of the committees are appointed by the Minister of Labour. In order to inaugurate the system of Local Committees, meetings of the chairmen are being held in different parts of the country.

Sir Auckland Geddes has appointed a committee to advise the Ministry of National Service on questions of part-time labour, with a view to securing the fullest use on work of national importance of all forms of part-time work, and the co-operation of voluntary organisations which are in a position to undertake the effective organisation and administration of part-time schemes.

On Thursday, the 6th inst., Lord Claud Hamilton presided at the prize distribution of the Great Eastern Railway Mechanics' Institute, and stated that owing to the exceptional circumstances which had arisen, the war might continue more than another 12 months. He added that there had been an inflated rate of wages—wages which many people considered higher than necessary, and wages were sure to decrease at the close of the war, but one thing was certain, that the low wages which existed previous to the war would never again be re-established. There would be a higher rate all round, and higher conditions of life in every respect. If, however, foreign competition was to continue as in the past, it would be necessary for great employers and the leaders of industry to think of production first and of cheapness afterwards. Production would have to be of a higher quality, which meant harder work, and it would be necessary to place an *ad valorem* duty on goods manufactured outside the United Kingdom. The nation might have to pay rather more for its goods, but they would be better goods, and there would be the great advantage of higher wages.

An interesting article is published in *The British South African Export Gazette*, stating that before many years have elapsed Pretoria may develop into a great industrial centre for the production of iron and steel, and become a "Sheffield" in miniature. It has always been known that abundant deposits of iron ore of a quality which makes it extremely valuable from the commercial point of view exist in the Pretoria district, but it is only recently that the Corporation has taken the definite step of leasing to a local company a small portion of the ore-bearing area. The company in question has been promoted by Mr. C. F. Delfos, of the well-known engineering firm of Delfos, Ltd., Johannesburg and Pretoria, and a blast-furnace to treat the ore, as also that found near Barkly West, in the Cape Province, will shortly begin operations. Inquiries have been received from other quarters and from other persons who desire to take a much larger share in the mining of iron in the region, but the Municipality finds itself handicapped by its inability under the Local Authorities' Land Ordinance of 1916 to grant leases of longer duration than 20 years.

The manufacture of steel, the *Gazette* continues, has already taken place quite successfully in the Transvaal, even although the industry may be said to be still in the experimental stage. The first electric furnace of the induction type to be erected in South Africa was put down a few months ago by the Witwatersrand Co-operative Smelting Works under the auspices of the Chamber of Mines for making steel castings, such as shoes and dies for the mines, from scrap metal. The manufacture in the Transvaal of iron, &c., from scrap has been carried on at Vereeniging for several years, its production in 1916 having been 1,635 tons of light rails, 4,650 tons of ingots, 450 tons of structural steel and 2,417 tons of merchant steel. Between 70 tons and 80 tons of shoes and dies are now being turned out per month by the electric furnace referred to. The lining of the furnace at first presented some difficulties, but these were solved by the use of magnesite from the Eastern Transvaal, calcined at Johannesburg. At the Danswart Iron & Steel Works, Limited, something like 400 tons to 500 tons of bars and angles are now being produced monthly from selected scrap, but the scrap supplies are far from inexhaustible, and it is highly essential that pig-iron should become available without unnecessary delay.

So as to be better able to grapple with the apprehended unemployment during the forthcoming winter, which is likely to be materially enhanced through the increasing shortage of raw materials of every description, the Danish Government has decided to appoint a commission, on which the Ministry of the Interior, the Traffic Ministry, the public employment bureau, the employers union, and the trade unions, with other interested bodies will be represented. Both the State and the different municipalities will do what they can to advance public works. At the same time the men often make unreasonable demands. Thus the hands employed in unloading work for the Copenhagen Corporation struck for higher wages, although they earned about 12*s.* per day; they were accorded a rise of 50 per cent. on account of the high ruling prices. The stationary arbitration court has sentenced the smiths and machine workers union to pay a fine of 280*l.* for having boycotted a certain firm. The boycott was declared because the firm had discharged some hands, who remained sitting at a public house after the breakfast-hour. The same court some time ago sentenced the shipyard workmen's union to pay a fine of 1,800*l.*, but the union distributed its funds in hand of about 2,200*l.* among its members before arrest could be made. The union was then declared bankrupt, and the curator of the bankrupt estate has now summoned some 800 members of the union to refund the money they had thus received.

Dealing with the last issue for December of the Amalgamated Society of Engineers' Journal, *The Glasgow Herald* states that officially, of course, the A.S.E. has so far had nothing to say on the question of the restoration of pre-war conditions. Unofficially, however, a good deal is being said by members, and the bulk of it is to the effect that it might be to the advantage of the society to trade away some of the "rights" for concessions in other directions by the Engineering Employers' Federation. One of the rank and file, writing in the December Journal, indicates the character of the concessions which are, in his opinion, possible. The industry will "presumably," he says, be able after the war to "afford present-day standard time rates and bonuses"; priority of employment could be guaranteed to skilled workers whose unions might be given, the writer thinks, control of "a lighter disciplinary code." Payment by results could be made the subject of collective bargains between employers' federations and trade unions. The character note could be abolished, the employers' arbitrary right to discharge curtailed, the eight-hour day introduced, and all "obnoxious workshop rules and regulations removed." "A lot will depend," this engineer thinks, "upon the results of the peace conferences with the employers' federations. Given an unsatisfactory settlement, the unions for years after may be forced to confine their energies merely to a fierce fight for existence." He does not, however, see any reason why that should happen, provided unity is preserved in the ranks of labour, "and a wise use is made of the law—shortly to be further strengthened by an amending Act of Parliament—guaranteeing the restoration of the pre-war position."

The second report, White Paper 167, is now issued by the Select Committee of the House of Commons on National Expenditure. Among the points with which it deals are those which concern wages and the cost of living. In regard to these, it states that demands from the working classes for war bonuses or wage increases are based on one or more of the following grounds:—(*a*) The cost of living has increased, and wages must be increased also in order to enable the working-class family to pay its way. (*b*) The employing class is making large profits out of the war, and so long as they do so, it is legitimate that the working classes should do the same. (*c*) The demand for labour exceeds the supply, and it is inevitable, therefore, that wages should rise. (*d*) The worker's output has been increased, and he is entitled to a higher wage in consequence. (*e*) Increases have been given in one industry or in one grade, and in order to prevent inequality or unfairness, increases must follow in other industries or grades as well.

In their comments on these points, the Committee refer to the Board of Trade's statements as to the increase in food prices in November which we have given above in abstract. With reference to large profits, it is pointed out that 80 per cent. of these profits, in excess of the pre-war standard, is taken by the duty, and, excepting small or moderate incomes, one-fourth of the remaining 20 per cent. is taken in income-tax and a further proportion in supertax. Moreover, the profits of munition manufacturers, shipowners, coalowners and many classes of food producers are now restricted. Increases of wages received apart from any question of the cost of living are a direct cause of further rises in prices and increases in national expenditure. It is essential that if labour is asked to forego the advantages of its economic position from motives of patriotism, the same measure should be effectively applied to capital. Each advance in wages results in a further increase in prices, or in preventing a reduction of prices. The producers raise prices against themselves as consumers. In the meantime, the cost of the war is vastly increased. The Committee are deeply impressed by the seriousness of the question in this respect, and are convinced that if the prices continue the result can hardly fail to be disastrous to all classes of the nation.

The Committee recommend that an enquiry be set on foot to ascertain what has been the actual increase in the cost of living to the working classes, and how far it has been counterbalanced by advantages apart from wage advances due to war conditions. The measures for the limitation of profits should be continued and strengthened, and should be made more widely known to the people. The strongest case should be required to be established before any advance of wages is con-

ceded on any ground other than the rise in the cost of living. Nor should it be regarded as a rule that wage-earners in receipt of not inadequate pay before the war should be exempted from all share in the economic sacrifices involved by a state of war. A single policy under the general direction of one authority should be adopted in all industries in the determination of wages questions.

THE MILITARY AUTHORITIES AND ENGINEERS.

To the Editor of Engineering.

Sir,—I have been desired by the Council of the Institution of Civil Engineers to refer to a statement contained in a letter published in your issue of December 14, to the effect that your correspondent gathers that "The Institution of Civil Engineers has done nothing to protect its members from an intolerable situation" in respect of their treatment by the military authorities.

Your correspondent's information is, however, incorrect. The military authorities have been, on several occasions, approached by the Institution Council in the interests of those of its members who are in the army, and those representations have been at all times cordially received and generally considered favourably. The council have also been approached by the War Office from time to time for advice and assistance in such matters, and it is believed that the information given has been found of value.

It is not within the province of the Institution to discuss the regulations as regards the rank of any class of the Engineer Establishment of the Army, but as regards the Corps of Royal Engineers generally, the council are aware that endeavour is made by the military authorities to apply the service of trained engineers in suitable capacities and to recognise that service appropriately by authorised rank.

Yours faithfully,
J. H. T. Tudsbery,
Secretary.

The Institution of Civil Engineers, Great George-street, Westminster, S.W. 1, December 19, 1917.

THE NEW PATENT BILL.

To the Editor of Engineering.

Sir,—I have read with some interest your article which appeared in Engineering of the 7th inst., on the above subject, and whilst agreeing with your friendly criticism and hope that the amended Bill may possibly prevent the abuse of the monopoly rights under patents, encourage invention and the taking out of patents, and secure that new inventions shall, if possible, be worked on a commercial scale in the United Kingdom without undue delay (as you have put it), I am of the firm opinion that it may have the opposite effect.

It should be borne in mind that a patent at present is simply a contract entered into between the Government and the inventor, by which the inventor is bound to make public every detail of his invention and produce drawings, so that any ordinary practical man can afterwards work from them. The inventor thus hands over the result of his brain labour to the nation, and he only gets the privilege of exclusively using and controlling his own invention for at most fourteen years on his paying certain fixed charges. Should any of these annual fees not be paid, the patent from that moment becomes null and void. If, again, the fees are all regularly paid, after the term of fourteen years has been completed the invention becomes public property. As to protection, no real protection is given further than if the inventor has to go to law to uphold his rights, and ultimately wins his case—after having, perhaps, been practically ruined in law costs—the decision is upheld. The onus again of proof of the validity of any patent attacked lies entirely on the patentee or inventor.

During the past thirty years it has been one's duty and privilege to point out the imperfections of the British patent system, and latterly the weak points the much-belauded Patent Act of 1907, the amendment of which Act is now apparently being attempted by the new Bill forthcoming.

Your reference to, and qualified approval of, the proposition to amend Section 24 of the 1907 Act by adopting in principle the "working" conditions by "endorsement" of the Canadian Patent Act appears to me to be rather unfortunate, as from my own experience that is going to be a retrograde rather than a progressive step. In fact, without going into too much detail, may I suggest that in my opinion the Canadian patent system appears to my mind to be one of the most crude and parochial arrangements conceivable, and is apparently designed principally for the purpose of enabling Canadians to nobble in due time inventions from this and other countries without paying for them.

To my mind, the only good point in the Canadian patent system is the eighteen years period during which a Canadian patent is in force, as against our fourteen years. You say, "it is now proposed that British patents shall be granted for a term of fifteen years, thus bringing British practice into line with that of many foreign countries": to this the pertinent query might be asked, which foreign countries? The granted term in Germany is fifteen years, as I think it is also in France, but what of our great ally, the United States, where the term is seventeen years.

This brings us to the main question, viz., what is the matter with the patent system of the United States of America, and why should we not make that practically perfect system our copy rather than the more or less ancient and autocratic patent systems on the Continent? The Americans have copied many things from us: it should now be our turn to imitate them in all that is good and has been proved to be good in regard to invention, their manner of encouraging it, and their unrivalled patent system, if, again, the Americans are rightly proud of anything, it is of their patent system, which is as different from our as day is from night: for instance, in the United States, no patent is granted until it has been shown that the invention is absolutely novel, the total Government fees for a term of seventeen years amount to only 7*l.*, paid once and for all: the Patent Department is self-supporting, there being millions of dollars in solid cash always lying to the credit of the Patent Office in Washington, and the accumulated surplus is used solely as a reserve fund for further perfecting the machinery of the department. How stands the comparison with our British patent system? Practically anything can be patented provided there is nothing *identical* in every respect to be found in the British Patent Office during the previous fifty years: the total Government fees for a term of fourteen years amount to no less than 99*l*: a huge revenue is annually extracted from inventors which passes into the hands of the Chancellor of the Exchequer, while (in comparison with the American Patent Office) the Patent Department is worked from hand to mouth and is practically starved.

May I be allowed to mention a particular example in order to show what—under the present *regime*—the value of a British patent may be and what the so-called search by the British Patent Office before granting the patent really amounts to? Some years ago a British patent was granted to an outsider for an "invention" notwithstanding that the specification and drawings clearly showed that it was a deliberate copy of an existing British patent of six years previously. The original and *bona fide* inventor was advised that his only course was to take revocation proceedings against the pirate in the High Court, which was done. The offender made a pretence of defending, and managed by one excuse after another to drag the case on for nearly two years, and when ultimately, the High Court ordered the revocation, with cost against the offender, it was found he had decamped and left the victim to pay!

So much for the "protection" of the inventor under the present Patent Act, nor can I find more protection under the proposed new Bill. In strange contrast, however, I find that under Section 84 of the new Bill the interests of patent agents are fully looked after, so much so in fact, that it would appear as if it were to be a penal offence for anyone else after this but a patent agent to advise an inventor in the taking out of a patent: hence, one may have a very good guess as regards the real professional origin or inspiration of the new Bill! Where, however, may the inventor come in under the new Bill, seeing it is he alone, after all, who ultimately gives the benefit of his invention to the country, and who all through really pays the piper?

Yours faithfully,
December 16, 1917. James Keith.

ACTION OF CAUSTIC LIQUOR ON STEEL PLATES.

To the Editor of Engineering.

Sir,—With reference to the memorandum by Mr. Stromeyer, which you published in your issue of the 14th inst., perhaps the following observations from one who has had personal experience of over 100 evaporators, of all kinds, comprising some 100,000 tubes of every make, might be useful.

Firstly, regarding the well-known break in the tubes of an evaporator:—

(*a*) No tube has ever been known to break except at the ends.

(*b*) The ends of the tubes only differ from the other part as the result of annealing (the ends are usually annealed to facilitate expanding).

(*c*) That a Mannesmann tube has never been known to break in this way.

(*d*) That any tube that breaks will, on examination, be found to develop "hot short." (If Mr. Stromeyer will cut out two portions from the middle of a broken tube, anneal one, and flatten them both, he will find that the unannealed one will work well whilst the annealed one will break.)

(*e*) That this peculiar breakage is not confined to caustic soda, but is met with in nearly every kind of liquor.

(*f*) That the breakage occurs within a few weeks of the starting of the evaporator.

(*g*) That it is, therefore, probable that the crack exists as the result of expanding an annealed portion of a tube which is not suited for annealing and does not immediately develop for reasons given hereafter.

A small evaporator which the writer recently designed for very high strength caustic liquor, was fitted with 400 Mannesmann tubes annealed all over, and seven tubes of a well-known make annealed at the ends. One of the seven cracked in a fortnight. The others are showing signs. The 400 annealed tubes are perfect. This evaporator works under the most drastic conditions.

Secondly, regarding the leakages on riveted joints. This also applies to the cracking of tubes (see (*g*) above).

Caustic soda is well known as about the most "creepy" substance in existence. It will penetrate through an opening impervious to water or steam at many times the pressure. In a riveted joint, as I view it, a little caustic makes its way through to the surface, there meets with the air and gradually forms carbonate of soda. This, by capillary attraction, absorbs still more caustic liquor, and the action proceeds until the accumulation of carbonate between the joints becomes large enough to force the rivet heads off. The joint then opens and leaks.

Both the above points are very fully dealt with in some articles I contributed to *The Chemical Trade Journal* in June and July of this year.

Yours obediently,
December 18, 1917. Ernest Worsley.

DRAUGHTSMEN.

To the Editor of Engineering.

Sir,—With reference to the correspondence appearing in your valuable paper on the status of draughtsmen, it would appear that some of your correspondents have got away from the realities of the situation.

In the ranks of draughtsmen there are men of various degrees of training, from that of glorified tracers to men having engineering degrees, and it is difficult to say offhand what is the status or position of draughtsmen in relation to others in and out of the engineering world.

It is the practice in some of the large firms to admit into the drawing office by means of an examination a number of works apprentices. It is unfortunate that this is not general, and made to apply to all men entering the drawing office. Had this been so there would have existed some standard by which to judge the status. We have the terms "first-class draughtsman," "senior draughtsman" and "junior draughtsman." What is a first-class draughtsman—a senior draughtsman? Are these just men who have spent a certain number of years at the drawing board. The whole position is very vague. The word draughtsman hardly meets the case of a man having a high standard of technical training. The word designer would be better, and might be used for men having a certified standard of training.

At present there is no definite technical training of draughtsmen, attendance at evening classes or a course at a correspondence school being purely optional in many cases. There are draughtsmen who do not know what a logarithm is, who cannot solve a quadratic equation, while there are others who, calling themselves mechanical draughtsmen, are ignorant of what is meant by the modulus of the section. I will be told by some that it is not necessary for the average draughtsman to know these things, that his work consists mainly in copying and modifying existing machines, which requires only a knowledge of arithmetic, and the use of the pencil. This only goes to confirm that the draughtsman is a workman. How often is the young draughtsman told to look upon the pencil as a tool just as the mechanic regards his chisel and file?

Professional men forsooth! Yet this is the calibre of the men who look down upon the workmen in the shops. How fiercely the members of the Amalgamated Society of Engineers will resent the presumption of draughtsmen who are to-day simply following in their wake in asking for war bonus, 12½ per cent. bonus, &c.

Having been compared to doctors and lawyers, draughtsmen are now asked to sup with the foremen, and to lament the fact that they do not receive the same consideration of their claims. Foremen are overseers of labour, and it requires very little intellect to see that in the nature of things they will receive more support than the workers either in the shops or the drawing office.

The Association of Engineering and Shipbuilding Draughtsmen appears to be attempting to sit between two stools, that of a trade union and an education society. The only logical *role* for the Association of Engineering and Shipbuilding Draughtsmen is that of a trade union, for you cannot get the pre-war standard of the draughtsman's wage, standard hours, payment of overtime and freedom of movement by merely passing unanimous resolutions as the officials of the Association of Engineering and Shipbuilding Draughtsmen will have found out by now. You must act on trade union lines.

Yours sincerely,
Harold C. Clausen.

5, Leighton Buildings, Westminster, London, S.W. 1, December 17, 1917.

Extension of German Shipyards and Shipping Companies.—The Blohm and Voss shipyard in Hamburg is about materially to extend its site by an arrangement with the neighbouring Janssen and Schuislinski yard. This latter undertaking will then move to a site, 9.4 acres in area, on the left side of the Elbe at Pollerort. The Howaldt yard in Kiel is increasing its capital in order to be better armed to meet the contingencies of the future, and so are several shipping concerns. Thus the Hamburg Shipping Company of 1896 is doubling its capital, from 2,500,000 marks to 5,000,000 marks and the New Steamer Company, of Stettin, is increasing its capital from 3,167,000 marks to 4,500,000 marks.

Belgian Mining Company.—The Lothringer Hütten und Bergwerksverein Aktiengesellschaft, the old Belgian Aumetz-Friede Co., has now been formed, with its domicile at Nilvingen in Lorraine, with a share capital of 58,000,000 marks and 36,000,000 marks debentures. The Aumetz-Friede Company, the assets and liabilities of which have now been taken over by the new German company was started as a Belgian concern in 1897. It first applied itself to the Lorraine property, but by degrees it directed its attention also to Rhineland and Westphalia, and in the year 1910 the mines of Ickern and Viktor were acquired, two years later co-operation being established with the Mamestaldt rolling mills at Kalk near Cologne and the Düsseldorf Iron and Wire Industry Company. The majority of the shares eventually came into German possession.

FABRICATED SHIPS.*

By R. H. M. Robinson, Member of Council.

Recently the term "fabricated ships" has become one of public interest. A fabricated ship may be defined, briefly, as a ship on which the work of punching and shaping the plates and shapes and, to some extent, assembling and riveting, is done in a fabricating shop, ordinarily employed for bridge or tank work, as distinguished from the usual practice of doing it in a shipyard punch shop. So far as the writer knows, the fabricated ship is a product of American progressiveness. The writer claims no credit for the idea or for its development, and hardly knows why he should prepare a paper on the subject unless it be that he has the honour to be connected with two companies now constructing ships on this system, one of which may reasonably claim to be the first to do so. The principal credit for carrying out the fabricating idea is due to Mr. C. P. M. Jack, now consulting engineer, and to Mr. Max Willemstyn, engineering manager of the Chester Shipbuilding Company and of the Merchant Shipbuilding Corporation, and it would be improper to neglect to state that the ideas of Messrs. Jack and Willemstyn could probably not have been carried out, except for the interest and assistance given them by Mr. Jas. A. Farrell, president of the United States Steel Corporation, and by the officials of the American Bridge Company.

The construction of fabricated ships makes it possible to have the steelwork done by those who are specialists in the line of fabricating steel with all of the special tools and labour-saving devices at their disposal. It relieves the mind of the shipyard operator from the multitude of detail that goes with such work, reducing his problems to those of engineering, erection, riveting and assembling by the workmen, and to the installation of other units of outfit and equipment.

The type of ship which the Chester Shipbuilding Company has built, and which it and the Merchant Shipbuilding Corporation are now building, provides for the use in all places of conventional ship shapes and ship plates, subject to the rules, inspection and survey of the registration society, both as to quality and material, dimensions, riveting and other matters. These vessels are cargo carriers of about 8,800 tons to 9,000 tons deadweight capacity with poop, topgallant forecastle and bridge, the latter being about 124 ft. long. The decks, with the exception of the poop and topgallant forecastle, are without sheer at the centre line. Complete double bottom for the carrying of fuel oil or water ballast is fitted. The machinery is located amidships and consists of high and low-pressure turbines driving a single screw through reduction gears.

In the emergency which has recently arisen there have been proposed ships constructed from bridge shapes and universal mill plates with regard to which the writer has no personal detailed knowledge. It would appear to him that there might arise certain difficulties in using this character of material in the construction of ships, but he would prefer to leave to those who are personally cognizant of the matter any questions in regard to this.

During the late winter of 1912 there was a sudden demand for oil tankers, while freight charters were low and cargo ships plentiful, and almost anything which could be made into an oil tanker was used. Mr. Jack then conceived the idea of using a system of vertical cylindrical tanks which were to be built and tested ashore, then installed bodily in the steamer. Two cantilever-type colliers, the Borgestad and Fritzoe, were acquired under long-term charter. Contracts with Pittsburg tank builders and New York pipe fitters and shipwrights were entered into. The tank builders started to erect the steel (amounting to about 900 tons) long before the arrival of the steamer, and by June the loading of the tested tanks in the Borgestad was begun, and the actual loading was finished in 10 days. It is needless to say that almost unsurmountable difficulties had to be overcome—in the first place, on account of the use of cylindrical tanks for ships; secondly, because of the manufacture of these tanks by tank-builders, the riveting by house-smiths and several other "objectionable" features which were not done according to old-time custom. Mr. Jack, during this time, spent several months in Norway to adjust matters with the classification society and had to withdraw the second ship from their class and change to Lloyds. The first ship sailed in September, 1913, without class, which was only, again, assigned after a trial of three months.

During 1913 the Escalona, then building at a British yard, was changed into a cylindrical tanker, but, due again to difficulties of classification, horizontal tanks were installed. These tanks were also manufactured and tested complete outside the shipyard. In the fall of that year three ships were started in Great Britain on the general design of the tankers now building at Chester, but the shipyard would extend the fabricating portion only to the cylindrical tanks.

In 1914 the Chris Knudsen and the Mills were converted on this side. The former was on the type of the Borgestad. A new departure was made with the Mills. The tanks in this ship were connected to tank-top and deck, a trunk built on deck and connections made from tank to tank and to the ship's side, thus forming cylindrical tanks and spaces between tanks and shell, with oiltight centre line bulkhead between tanks. Practically all the material was ready for assembly when shipped from Pittsburg. All holes were punched and countersunk, and stiffeners riveted to trunk sides, centre line, &c., wherever possible before shipping. The only pieces which were left blank were the outstanding leg of bounding angles connecting to the old ship's structure, and one edge of the transverse bulkheads. On account of the peculiar dome roof construction of tanks, which dome formed into a rectangular trunk, only about 60 per cent. of the material was multiple-punched and the balance single-punched. The ships converted at New York were all erected with regular tank builders' outfits, consisting of a gantry or stiffleg derrick, air compressor outfit, blacksmith's forge and one or two ship fitters. All piping, ventilating, &c., was fabricated beforehand, except the closing pieces.

The above experience is given in some detail as it was gradually leading toward the fabricated ship, but in taking up the fabricated ship as a whole another difficulty arose on account of the size of the job involved in fabricating complete ships, involving thousands of tons of steel instead of hundreds. The tank manufacturers previously engaged could not entertain the proposition, and others were quoting prices which made the undertaking impossible commercially. The American Bridge Company, however, after several months of search and discussion, decided to fabricate two ships, but would only undertake to do the absolutely parallel midship body. About 60 per cent. of the total steel weight of the first two ships was thus manufactured. This was increased to 70 per cent. on the following ships, and to-day the bridge shops have contracted for 85 per cent. of the hull steel and will fabricate also part of the curved portion of the ship. Of course a 100 per cent. fabricated ship is possible, but with the present bridge-shop equipment this is not obtainable. They will first have to increase their furnace facilities to take care of the bending of frames and the bevelling of angles, which may be done in the near future if the standard ship is here to stay.

The manufactured ship is a commercial possibility only if duplicate ships are built and, therefore, this policy was adhered to as far as possible from the beginning in contracting for the ships at Chester, there being but four different classes. These classes are as follows:—

1. Tank ship of about 9,000 tons deadweight capacity, fitted with cylindrical tanks on Jack's system. The vessel is built with topgallant forecastle, poop and short bridge. The main deck at centre line and top of expansion trunk are without sheer. Cylindrical tanks extend from tank top to under side of main deck, and a continuous trunk extending between poop and topgallant forecastle takes care of expansion and provides a working deck between the bridge, poop and forecastle decks. Machinery is located aft and consists of a high and low-pressure turbine driving a single screw through reduction gears.

2. Two-decked freighter of about 8,800 tons to 9,000 tons deadweight capacity, having poop, topgallant forecastle and bridge, the latter being about 124 ft. in length. This vessel is built with sheer. Complete double bottom for the carrying of fuel oil or water ballast is fitted. Machinery is located amidships and consists of high and low-pressure turbines driving a single screw through reduction gears.

3. Shelter-deck freighter of about 9,300 tons deadweight capacity, having poop, topgallant forecastle and bridge. Complete double bottom for the carrying of fuel oil or water ballast is fitted. Machinery is located amidships and consists of high and low-pressure turbines driving a single screw through reduction gears.

4. Two-decked freighter of about 8,800 tons to 9,000 tons deadweight capacity, having poop, topgallant forecastle and bridge. The decks, with the exception of the poop and forecastle decks, are without sheer at the centre line. Complete double bottom for the carrying of fuel oil or water ballast is fitted. Machinery is located amidships and consists of high and low-pressure turbines, driving a single screw through reduction gears.

Except as to details, which may be modified to provide ease of fabrication, the fabricated ship does not differ essentially in structure from any ship of a similar class. One of the prime questions involved is that of multiple punching. The greatest difficulty with the arrangement for multiple punching lies in the fact that the minimum distance from centre to centre of punch dies in a multiple punch is regularly 2 in., which distance can occasionally be reduced to 1¾ in. The term "multiple punch" implies that the spacing of rivets is to be laid out so that the spacings of rivets in different successive rows are in multiples of each other or in multiples of 2 in. Take, for example, a butt spacing of four diameters of ¾-in. rivets, equal to 3¼ in. The frame riveting in this case could be six diameters, or 5¼ in., which is no multiple of 3¼ in., and neither is 3¼ in. a multiple of 2 in. A compromise is made in this case by making an average butt spacing of 3¼ in., which can be done by spacing in groups of three, viz., 3½ in., 4 in., 3½ in. The punches for the butt and frame spacing would be spaced in the machine as follows: 3½ in., 2 in., 2 in., 3½ in. The first, second, fourth and fifth punches would be used for the butt spacing. The first, third and fifth for the frame spacing, allowing for a 5½ in. spacing. Where the butt spacing is 3¼ diameters and the frame spacing 7 diameters, such as on smaller size ships, there is not much trouble, but the multiple punch is hardest to apply on the 9,000-ton, clear-hold, single-deck ships, with their 5¼ and 6 diameters frame riveting. Again, on the larger ships, with 4-in. butt spacing it is easier to be according to rule, and it should be here noted that Lloyd's Register of Shipping has been very progressive and broadminded in allowing the use of the average spacing instead of the strict and absolute adherence to stated rules.

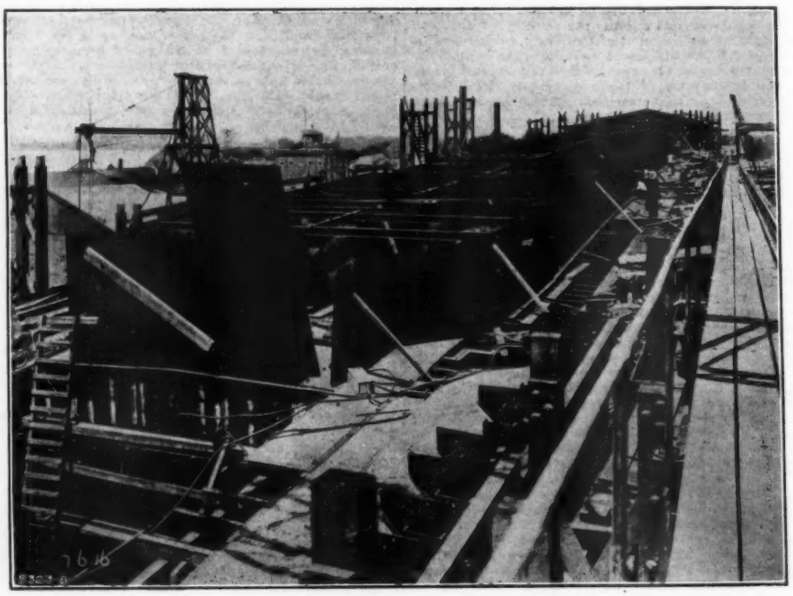


Fig. 1. Fabricated Ship on the Building Berth.

The first thing to do on a ship designed for multiple punch is to arrange the midship section in such a way that all longitudinal rows of holes fall in line with the principles just explained; second, to arrange the plate width so that the greatest number of equal width plates are obtained; third, to see that, if possible, each plate is symmetrical about the long centre line of the plate, so as to avoid any possible countersinking errors. No templates are required for setting the multiple punch, which is entirely done from the typical rivet spacing drawing.

In staggered riveting, the minimum longitudinal spacing between the rivets of one row and those of the other is 1 in., but 1¼ in. is preferable. This space is required for the stops and pawls, which stop the table during the downward stroke of the punch-head. It is, of course, possible to reduce the minimum space to small fractions, but then the human element of error is introduced, as a man has to insert a liner between stop and pawl, equal in thickness to the change in spacing wanted. Otherwise the machine is electrically controlled, except the throwing in of the clutch for punching.

A "pole," being a batten about 3 in. wide by ¼ in. thick, and of such length as required, is used as template for the longitudinal spacing. Steel stops are inserted in the holes of the batten corresponding with rivet spacing, or, on the newest machines, steel stops are set up in a steel rack to suit the pole. Different colour of light is shown where butts, edge-seams, frames, &c., occur, and the man on the levers is acting solely according to these colours.

The multiple punches have, as a rule, only three or four set-ups, that is to say, one set-up for butts, one for

* Paper read at the meeting of the Society of Naval Architects and Marine Engineers, New York, November 16, 1917.

LONGITUDINAL SECTION AND DECK PLANS OF FABRICATED SHIPS.

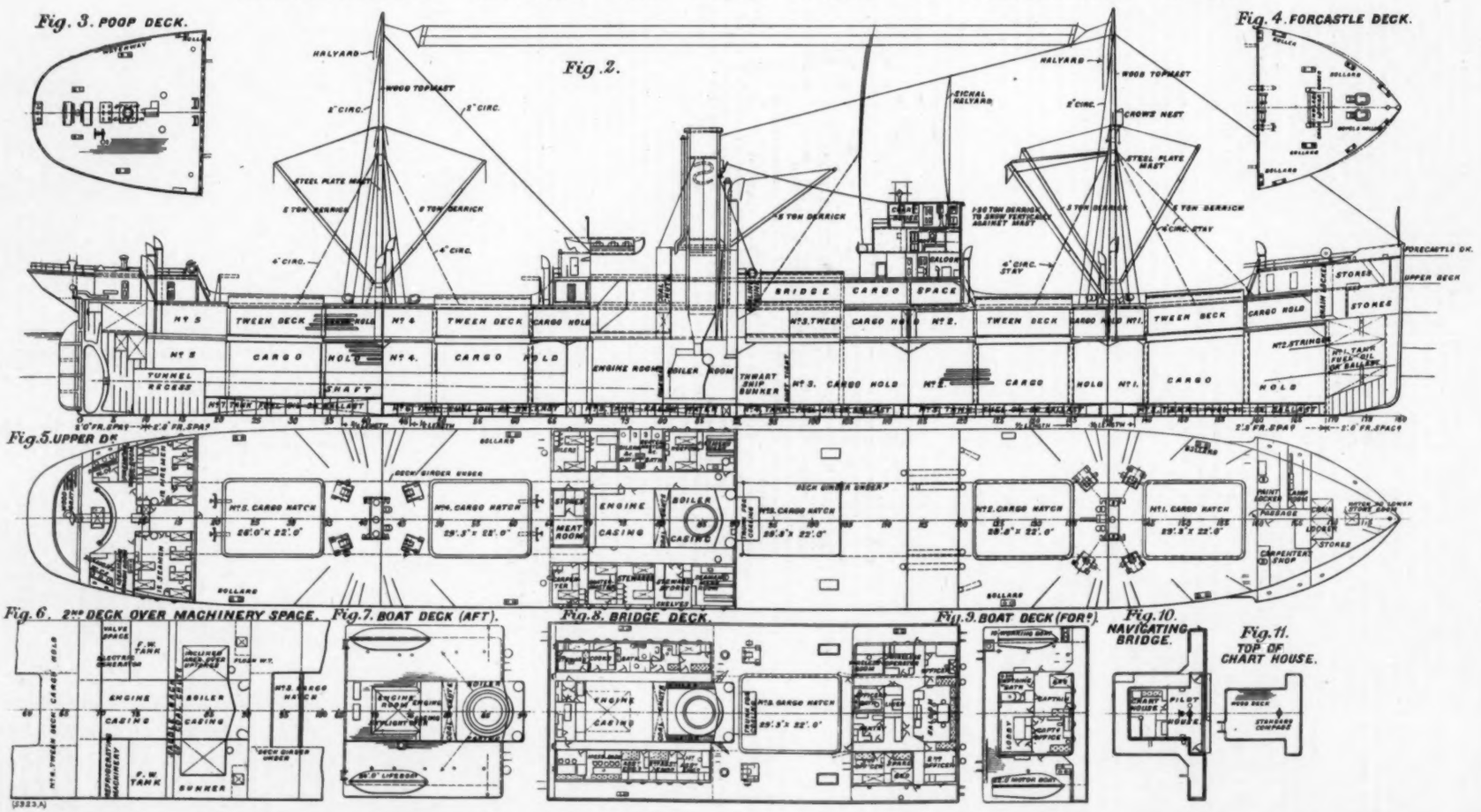


Fig. 3. POOP DECK.
Fig. 2.
Fig. 4. FORCASTLE DECK.
Fig. 5. UPPER DK.
Fig. 6. 2ND DECK OVER MACHINERY SPACE.
Fig. 7. BOAT DECK (AFT).
Fig. 8. BRIDGE DECK.
Fig. 9. BOAT DECK (FOR.).
Fig. 10. NAVIGATING BRIDGE.
Fig. 11. TOP OF CHART HOUSE.

edge-laps, one for frames, one for, say, intercostal angles in conjunction with the edge-laps. In this case the watertight bulkheads could not be punched if the holes would not entirely coincide with one of the four set ups. It is possible to omit a few holes in some of the set-ups, but this is done only by hand. The man on the punch can release any number of punches temporarily by disconnecting the gag-operating gear for these punch dies.

The Chester Shipbuilding Company, Limited, has, wherever possible, carried out the idea of duplication and standardisation, but very often has had to abandon it in the detail. The hull, engines, boilers, and, in fact, all large items for a group of ships have been duplicated. The dimensions for all but two ships contracted for by the Chester Shipbuilding Company are: Length, 401 ft.; moulded breadth, 54 ft.; moulded depth, 32 ft. 9 in. Some have had sheer, but, in the latest type, sheer is dispensed with and a raking forecastle and poop substituted, giving the effect of sheer, but simplifying the work of manufacture. The results of the fabrication in the Bridge Company's mills as outlined above is beyond criticism. Work is fair, rivet holes require no reaming, and the resulting fit of joints and watertightness is excellent. Constructing a ship becomes to a great extent a problem of routing, handling and erection of material and of riveting.

The Chester Shipbuilding Company, Limited, and the Merchant Shipbuilding Corporation are now building some 68 ships on the manufacturing principles outlined above. It is expected to embody even more than has been possible in the past the manufacturing idea, thus making it possible, in this day of labour shortage, to do a maximum of work with a minimum of skilled shipyard labour of the conventional kind.

THE OPTICAL SOCIETY.—At the meeting of the Optical Society, held on December 13, 1917, at the Imperial College of Science and Technology, there was read a paper by Mr. J. W. French, B.Sc., of Glasgow, on a "Proposed Standard System of Optical Notation and Sign Convention." The president, Professor F. J. Cheshire, occupied the chair. The author pointed out that owing to the non-existence of such standards, confusion often arises in the interpretation and use of optical formulæ, due to indefiniteness as to the sign convention employed in their construction. It is essential when designing optical work that has to be manufactured in quantity that there should be no such indefiniteness. It is desirable also that there should be a closer relationship between the practice of workshop designers and the teaching of the College instructors, so that the former may be able to profit by the work of the latter. As a first step in this direction it is necessary to adopt a common standard notation and sign convention, upon which future text-books would be based. The suggested scheme, which contained about one hundred clauses, dealt with the notation for points, lengths, and angles, and the sign convention for lengths and angles. Certain of the quantities were dealt with historically, as, for example, the substitution of the Greek letter, "μ" for "n" to represent a refractive index. It was suggested that the more controversial clauses might be discussed by a Committee which would issue supplementary lists that would ultimately cover all points, including the definition of terms and other standards. Mr. T. Smith, B.A., followed with a contribution on "Optical Nomenclature and Symbolism," in the course of which he dealt with the definitions of fundamental quantities, and conventions for positive directions, angles, curvatures, and powers. The necessity for a number of new symbols was shown; a special symbolism was required for oblique pencils. Mr. Smith set forth the new symbols which he proposed for frequently recurring quantities. The lettering and dimensioning of drawings and diagrams, the specification of optical systems, the methods of specifying aberration conditions, and difficulty of reconciling various systems were considered. The discussion on these papers is to be taken at the next meeting of the society.

AUTOMATIC AIRPLANE PROPELLER SHAPING MACHINE.

WE illustrate on page 662 an automatic propeller-shaping machine made by Messrs. Wadkin and Co., of Leicester. The machine has now been on the market nearly three years, and has been constantly developed and improved by incorporating in its design the practical suggestions of many propeller manufacturers. It is now widely used, many factories having a number of these machines working day and night.

The makers inform us that a 10-ft. two-bladed propeller may be cut in 1¾ hours by their machine at their standard rate of feed, which gives a very good finish to the work. Other rates of feed may be fitted to the machine if desired, which will enable a propeller to be shaped in 70 minutes with a slightly coarser finish. A four-bladed propeller is cut in exactly double these times. The amount of attendance required is small, and in some shops one man runs three machines, since they are entirely automatic, and merely require starting and stopping as each blade is cut, in addition to placing the work in and out of the machine.

The general character of the tool is shown in Fig. 1. Its mode of operation will, however, be best understood by reference to Figs. 2 to 11, which show the work in place on the machine. The blank is built up in the usual way by gluing together several layers of wood, as indicated in Figs. 2 and 3. The only change made, as compared with what is usual with hand-shaped propellers, is that the bottom lamina is left with a 4½-in. projection at each end. In each of these projections and on the centre line a 1-in. diameter hole is drilled to a template. The hole at the hub, which is put through at the same time, may either be bored out 1½ in. to suit the mandrel of the machine or bored out the finished size. If the latter method is adopted it is necessary to use a bush to fit the bore with a 1¼-in. diameter hole for the mandrel. The propeller block is placed over the mandrel of the machine, and sits on a faceplate, and is locked by a screwed nut as shown in Figs. 2 and 3. The extended tip fits over a steady pin and is locked by a hand nut.

The principle upon which the machine is based consists in forming a propeller blade by causing a roller to pass over the surface of an "original" (see Fig. 11), the path followed by this roller imparting a similar motion to the cutter arm as it passes over the work so as to cause the cutter itself to follow an exactly similar path.

Referring to Fig. 1, the bed consists of a long casting with machined ways, upon which a carriage is mounted. This carriage supports upon ways machined upon its upper face a reciprocating headstock. Upon this headstock are pivoted the cutter block and copy roller arms. These are connected at their ends remote from the cutting tool by an adjustable link. The arms are balanced by a spring, so that just sufficient weight is on the "original" as to keep the cutters in contact with the work.

The cutter block comprises 12 cutters of special shape, six cutters being on the front face of the cutter block and six on the opposite face, so that the machine will cut with equal facility in either direction. The designed speed of the cutter block is 4,200 r.p.m., and the spindle on which it is mounted runs in ball bearings. It is driven by a flat belt running over a two-step pulley, mounted on ball bearings and carried by a bracket fixed to the sliding headstock. A second flat belt running vertically downwards over guide pulleys couples the two-step pulley with the driving pulley, which is fixed and traverses with the carriage along a splined shaft. This shaft carries at one end a pair of fast-and-loose pulleys, and also a pulley for driving by means of crossed and open belts the carriage-feed mechanism. Steel reduction gearing contained in a gear-case connects the driven pulleys of this feed mechanism with a driving shaft for giving the reciprocating motion to the headstock on the carriage, and also for giving the longitudinal traverse to the carriage by means of a screw. Two stout horizontal turned bars, mounted in a pair of brackets, are used to carry the mandrels and faceplate for supporting the work and the "original" or copy. The method of mounting the propeller block upon the mandrel and the steady-pin at its opposite end has already been explained, and the "original" is mounted in exactly the same manner. It will be noticed that wooden guides (Figs. 6 and 7) are provided at each side of the "original" so as to provide a support for the roller on leaving the surface of the "original."

The "original" consists of a wooden block shaped on one side only, exactly as the finished blade for the face side, and a similar block for the back side. These are shown separately in Figs. 6 and 7 and Figs. 9 and 11, page 662. By adopting this method, a very stiff "original" is obtained, which can be quickly made by the manufacturer in his own shop. The wooden guides are fixed to quadrant brackets mounted on the "original" supporting bar, and can be locked in any suitable position. These platforms are shaped to suit the edge and faces of the propeller in order to give a smooth and easy motion to the roller arm as it passes backwards and forwards over the "original."

Owing to the variable shape of the propellers a motion is provided so that the "original" and the propeller block are tilted simultaneously by means of parallel links and a worm and worm-wheel motion, operated by hand wheel (best seen in Fig. 2) in order to facilitate the passage of the "original" roller in its traverse.

The machine is made in two sizes, viz., to take propellers up to 12 ft. and 14 ft. diameter, both of which will take work 9½ in. through the hub and 16-in. width of blade. The actual amount of time saved depends, of course, upon the size of the propeller, but taking the various figures given by propeller makers, the average is said to be well over 10 hours on a two-bladed propeller, and is in some cases as much as 14 hours. The actual amount of time saved by one machine resolves itself then into a simple sum, thus: Assuming a 60-hour week, and for easy reckoning assume 2 hours for a 10-ft. two-bladed propeller—time saved, $\frac{60}{2} \times 10$ —300 hours per week.

The machine can be seen in operation at the makers' works, and Messrs. Wadkin are, moreover, prepared on receipt of a sample blade to provide a statement as to the capabilities of the machine on the class of work submitted. The firm have, we may add, supplied other special machinery for aircraft work, and have found it necessary to considerably extend their works.

THE FARADAY SOCIETY.—A general discussion on "The Setting of Cements and Plasters" will be held on Monday, January 14, 1918, at 5.30–7 p.m. and 8.30–10-30 p.m. in the Rooms of the Royal Society of Arts, John-street, Adelphi, London, W.C.2. Dr. C. H. Desch (Glasgow) will open the discussion with a paper on "The Mechanism of the Setting Process in Plaster and Cement." Professor H. Le Chatelier will send in a communication on "Crystalloids *v.* Colloids in the Theory of Cements." Mr. A. A. Klein (Worcester, U.S.A.), will send in a paper on "The Constitution and Hydration of Portland Cement." Mr. George A. Rankin (Creighton, U.S.A.) will send in a paper on "The Setting and Hardening of Portland Cement." Mr. Bertram Blount will read a paper on "The Setting of Cement in its Relation to Engineering Structures." Mr. John Rhodin will read a paper on "Note on the Colloidal Theory of Setting." Mr. E. H. Lewis and Monsieur E. Deny (Wishaw) will read a paper on "The Effect of the Addition of Suitable Slag on the Setting Properties of Portland Cement." Mr. W. J. Dibdin will read a paper on "Ancient and Modern Mortars." Mons. R. Feret (Boulogne-sur-Mer.), Mr. A. Binns, Dr. E. B. Butler, Mr. W. J. Cooper (Penarth), Mr. Alex. L. Feild (Pittsburgh, U.S.A.), Dr. T. Martin Lowry, F.R.S., and Dr. J. W. Mellor will also contribute to the discussion.

NOZZLE CHARACTERISTICS.—The steam-nozzle characteristics, which Dr. G. Flügel, of the A.E.G. Turbine Works, Berlin, investigates in the *Zeitschrift des Verein, Deutsch-Ingenieure*, pages 650 to 655, of August 4 last, express the relationship between the reaction force or velocity coefficient at constant initial pressure before the nozzle and either the pressure after expansion or the adiabatic exit velocity. Flügel first deals with the average velocity, that is to say, that value of the velocity which is decisive for the energy supply to the buckets. He points out that the mean active velocity, the actual mean velocity and the mean square velocity might considerably differ from one another. In suitably-proportioned ("suitably-enlarged") nozzles energy should not be lost owing to condensation or oscillation, but merely owing to nozzle friction. For obliquely cut-off nozzles the velocity coefficient would not in general attain its maximum with the designed back pressure, as one might expect, but would continue to rise through a certain range with decreasing back pressure, and this the more, the worse the nozzle. This fact had first been observed by Christlein; it had been known in practice that insufficiently-enlarged nozzles were more advantageous than nozzles of theoretical proportions, but the reason had not been understood. There was an inferior limit of pressure for such nozzles; beyond this limit the expansion conformed to a new law. As regards nozzles with too great an enlargement the steam expanded normally up to a certain cross-section of the enlarged portion, to a certain back pressure p_1, and was subsequently compressed again to the pressure p_2. This rise in pressure was generally ascribed to the "direct gas impact," an explanation which Flügel considered improbable. Propagation of a disturbance at a velocity exceeding the velocity of sound could take place only at an angle—Flügel apparently means that the compression wave would tail off at an angle from the seat of disturbance—and it would, on the theory of streaming, be difficult to assume propagation of the disturbance in the direct straight line. It seemed more probable that the vapour stream did not remain in contact with the nozzle walls, when entering a much-enlarged cross-section, in which the velocity distribution was not uniform, and that a contraction developed as in the case of incompressible fluids. On this assumption the velocity coefficients could be calculated with a fair approximation.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The near approach of the holidays is responsible for a general speeding-up, and nothing is left untried to reach the maximum output of finished and semi-finished steel. High tensile bars and the shipbuilding material necessary for the requirements of the Shipping Controller are in particularly heavy demand, and, considering the circumstances of the closing down of the various producing works at the New Year, pressure for delivery is most intense. The persistency and the urgency of the home demands have further curtailed overseas trade, and less and less is now available for shipment. In this connection, ship plates rank prominent and are likely to continue so on account of the extensive programme being developed under the supervision of the Shipping Controller and his staff. No change has, as yet, taken place in the fixed prices for the different grades of steel, although it is growing more evident daily that further delay is prejudicial to the best interests of the steel industry as a whole.

Malleable Iron Trade.—Brisk business continues to characterise the malleable iron trade; home orders being so numerous that makers have difficulty in keeping pace with the demand; priority, therefore, becomes more than ever essential. While the bulk is on Government account, a considerable amount of agricultural and general mercantile work is being put through. Prices are still on the upward grade, round about 16*l.* per ton for "Crown" bars being the level just now, with even 16*l.* 7*s.* 6*d.* for an urgent order of some special brand.

Scotch Pig-Iron Trade.—Nothing could exceed the activity in the pig-iron trade at the moment, every brand being in such urgent request that not a single ton remains on the market, the entire output of hematite in particular going direct from the producing works to the steelmaking establishments in the near vicinity. The expected announcement relative to prices has not been made yet, so that home rates continue as where fixed, while those for export have considerably stiffened.

Steel Trade Labourers' Advance.—Intimation has just been received by Councillor Walker of the Steel Smelters' Society, and Mr. Owen Coyle, general secretary of the Amalgamated Society of Steel and Iron Workers, that, in response to their claim on behalf of bricklayers and general labourers in the steel trade, in Scotland, an advance of 5*s.* per week has been granted, thus bringing them into line with the skilled and unskilled steel workers. As in their case also the advance will be paid as from the first full pay in December.

BONE ASH CUPELLATION.—In assaying, the lead, carrying the precious metals and their impurities, is oxidised in a cupel made of bone ash, which is placed in a muffle furnace: the litharge (lead oxide) and other oxides are absorbed by the bone ash, and the gold and silver are found in a button of bright metal. Part of the precious metal is also taken up by the cupel, however, and that proportion seems to vary with conditions beyond the control of the assayer. Some experts ascribe to every cupel peculiarities of its own, others maintain that cupels of coarse or fine grain, hard and soft, give much the same loss. The subject has been investigated by Dr. F. P. Dewey, of the United States Mint Bureau, Washington, D.C. (Bulletin American Institute of Mining Engineers, November, 1917, pages 1,941 to 1,967). Assaying about 10,000 cupels of different makes and collecting data from other offices, he comes to the conclusion that much remains to be settled, and that the absorption by the cupel of silver in particular is not clear. The screen composition of the cupel does not seem to be the dominant factor. Temperature has a pronounced influence: but there are temperature fluctuations within the muffle furnaces, in which the cupels are arranged in rows, and even thermocouples do not really indicate the temperature of the bead or button which is the thing wanted. It is hence not possible yet to say what temperature should exactly be maintained.

AUTOMATIC DUST FILTERS AT DEPUE, ILLINOIS.—The dust and fume bags and bag houses are generally one of the most unsatisfactory and unhealthy features of mining and metallurgical plants. At the Nassau plant of the Mineral Point Zinc Company in Depue, Illinois, Printz and Race automatic bag machines were adopted in 1908: in these machines the bags were submitted to intermittent crinkling and snapping, and the gas flow was temporarily reversed by connection of the bags with the suction trunk. The device operated fairly well, except in cold weather when condensation troubles arose. Since 1914, Messrs. G. S. Brooks and L. G. Duncan (Bulletin of the American Institute of Mining Engineers, 1917, pages 1,933 to 1,938) have introduced a satisfactory system which deals with gases of 180 deg. C. maximum: hotter gases have to be cooled by dilution with air. The gas is delivered by a duct and led to a hopper and to the bags through a valve. This flow is maintained for a period varying from 4 minutes to 10 minutes. The valve is then raised, the duct is closed and connection is opened with the suction trunk: the bags then collapse. During suction the dust and trunk pressures are equalised. The actuating mechanism comprises a solenoid, a cam, levers and a horizontal rocking shaft, the resulting movement being jerky both vertically and laterally: during the shaking period the bags are under suction. The gas pressure variations in the bags amount to + 1 in. and − 1 in. of water. To deal with 1,000 cub. ft. of gas per minute requires about 1.5 h.p., at the rate of from 1 cub. ft. to 4 cub. ft. per square foot of filtering surface.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—There are not wanting signs that the general position so far as manufacturers are concerned is becoming more and more acute. This may be in a measure due to the tendency to accumulate reserves against the prospective stopping of the pits for the holiday season and the inevitable tightness which will ensue, but there is evidence to show that current requirements are growing larger almost week by week, and the utmost pressure is being placed upon the hard coal pits to maintain contract deliveries at the maximum figure. The export trade for neutrals is the only branch in which increased business is not recorded. Prices for inland transactions keep at the top level. Gas companies are eager to get additional tonnage, but are not meeting with very much success, and in certain cases the reserves in hand are not up to the usual figure. Slacks are wanted in heavy deliveries. The house coal position has strengthened up on the week, the call for more fuel being pronounced following the recent severer spell of weather. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.*, per ton at the pit.

Iron and Steel.—The majority of the large works will close down for a week to ten days on Friday night. This long holiday is really due to the fact that in between the normal holiday for Christmas and New Year there are only two working days, Thursday and Friday, and it is thought inadvisable to recommence then and close down on the Friday night once more for New Year. In the long interval much valuable work will be carried out in the form of overhauling, repairing and renewing plant. The output of the various classes of steel continues to be on a very good level, though there are one or two departments in which arrears have to be made up. The difficulty here is in keeping pace with the ever-growing specifications of the Government. In aero work, the increase has been phenomenal, for components of all descriptions have been ordered on a scale far exceeding anything we have yet experienced. The call for the special alloy steels is, therefore, very insistent. Nor can the steel firms find any relaxation in the constant demand for marine materials and parts. Standardisation has helped them in a measure, but the demand has grown very greatly, and the shipyards have to be kept fully supplied. Toolmakers also share in the shipyard activity, and big parcels are being despatched to the better-known firms containing the best brands of high-speed tools. The carbon varieties are also in heavy request. The production of files is not equal to requirements, and steps are being taken to extend it. Agricultural engineers are busy upon work for the coming spring. The orders on books for completed machinery are the largest they have known for some time. The plate and cutlery trades have had further orders from the Government and export customers.

INDUSTRIAL UNREST.—Messrs. P. S. King and Son, Limited, of Orchard House, Westminster, have issued a pamphlet entitled "Industrial Unrest," in which the reports of the Commissioners appointed by the present Prime Minister for the six English districts and the two Welsh districts, are collated and epitomised by Sir William Chance, Bart., M.A. The price is 1*s.* net.

THE DIAPHRAGM THICKNESS OF TELEPHONE RECEIVERS.—According to Lord Rayleigh the natural frequency of a circular plate diaphragm, such as used in a telephone receiver, should be proportional to the plate thickness and inversely proportional to the area of the plate. Some experiments made by Dr. C. H. Calder (see Journal of the Franklin Institute, November, 1917) in the Electrical Engineering Department of the Massachusetts Institute of Technology, do not quite confirm the first-mentioned proportionality, and they also show one reason why there should be a deviation from the law. The five pairs of diaphragms experimented with were of ferrotype steel, and ranged in thickness from 0.14 mm. up to 0.325 mm.: one diaphragm of each pair was japanned, the other not; this feature did not seem to make much difference. The inner diameter of the clamping circle was 5 cm. The tests were made by obtaining the motional-impedance circle of the instrument over a range of impressed frequency from 400 cycles to 1,500 cycles per second. It resulted that the natural (or resonant) frequency did not increase proportional to the thickness, but decreased first from 950 cycles to 900 cycles, as the thickness increased from 0.13 mm. to about 0.2 mm, and then rose to 1,175 cycles. The air gap changes would partly account for this deviation. The thinnest diaphragm was visibly attracted by its magnet and bulged inward, instead of being plane, so that the air gap was only 0.1 mm., whilst the thickest diaphragm had an air gap of 0.32 mm.: the diaphragm was hence not really a plate, but rather a stretched membrane. The sensitiveness of the instrument would depend upon the air gap, and on the mechanics of the diaphragm in general: the highest sensitiveness was observed with the diaphragm of 0.23 mm. The resonant range—defined as the difference between the two frequencies (greater and smaller than the resonant frequency) at which the kinetic energy of vibration under constant excitation by alternating currents falls to one-half—did not give a regular curve.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is a quiet feeling so far as Cleveland pig-iron is concerned. Home sales are very few and small, consumers being well bought. Supply of trucks is said to be rather better, so that deliveries show some little improvement, but the wagon shortage is still such as to leave no hope that anything like this month's heavy allocations will be anything like carried out. Some makers complain that owing to lack of facilities for distribution of their output they are having to stock pig-iron that is greatly needed for consumption. Foreign transactions are on only a limited scale, and substantial inquiries for shipments abroad over the first quarter of 1918 do not find makers at all keen to commit themselves to any extent. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all quoted 95*s.*, and No. 1 is 99*s*: and for shipment to France and Italy, No. 3, foundry and forge all stand at 116*s.* 6*d.*, and No. 1 is 121*s.* 6*d.* The stock of Cleveland pig-iron in the public warrant stores still stands at 608 tons, all of which is No. 3 quality.

Hematite Iron.—There is little new to report of the East Coast hematite branch. Conditions continue very strong and stringent. Steadily increasing output of basic iron promises to relieve the position considerably in the near future, however, and traders look for expansion of business. Meanwhile supplies to home customers are maintained on a scale sufficient to satisfy minimum needs. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Coke.—Demand for coke for local consumption keeps heavy, and as supply is ample, business is brisk. Average blast-furnace kinds are 33*s.* at the ovens, and qualities low in phosphorus 35*s.* 6*d.* at the ovens. Increased request for supplies is noticeable for export both to the Allies and to neutrals, and it is hinted that buyers abroad are prepared to pay higher prices than the official minimums. The export quotation of both beehive and patent-oven cokes is 45*s.*, and gashouse product is eagerly sought after at 39*s.* to 40*s.*

Manufactured Iron and Steel.—In the finished iron and steel industries manufacturers are kept very fully employed on Government work and material for the shipyards, so much so that they are altogether disinclined to entertain the rather numerous ordinary commercial inquiries that are in the market. Next week works will be closed, and opportunity thus afforded of carrying out much needed repairs and renewals to plant. To home customers common iron bars are 13*l.* 15*s.*: best bars, 14*l.* 2*s.* 6*d.*: best best bars, 14*l.* 10*s.*: iron ship plates, 15*l.* 10*s.*: iron ship angles, 13*l.* 15*s.*: packing iron and steel (parallel), 13*l.* 10*s.*: packing iron and steel (tapered), 15*l.* 15*s.*: steel bars (no test), 14*l.* 10*s.*: steel ship plates, 11*l.* 10*s.*: steel ship angles, 11*l.* 2*s.* 6*d.*: steel boiler plates, 12*l.* 10*s.*: steel joists, 11*l.* 2*s.* 6*d.*: and heavy steel rails, 10*l.* 17*s.* 6*d.* Exports are strictly limited to Allies' war requirements, and there are no fixed prices for sales abroad, but they may be given as approximately 40*s.* above home quotations.

THERMAL PROPERTIES OF SULPHURIC ACID.—It is surprising that the heat of dilution and heat of evaporation and other thermal properties of sulphuric acid, important for the concentration of the acid, should only have been determined in the neighbourhood of atmospheric temperature, between about 10 deg. and 20 deg. C. With this statement, however, Professor A. W. Porter, F.R.S., introduced a paper on "The Thermal Properties of Sulphuric Acid and Oleum," which he read before the Faraday Society on December 12. Concentration and dilution of the acid often take place at relatively high temperatures, and as the available data did not admit of making allowance for the temperature influences, Professor Porter explained two indirect thermodynamical methods he had applied, which, though so far unsupported by experimental observations, lead to the same results, and which enable the chemist to make his calculations both by means of tables and curves, and by means of an alignment chart, constructed so as to give the values corresponding to a solution containing m units of weight (grammes or pounds) of SO_3 in M units of water. The data from which Professor Porter started were the heats of dilution of sulphuric acid with various amounts of water according to Thomsen, Pfaundler, Brönsted and Knietsch (the chemist and engineer who worked out the contact process). The latent heat of evaporation of a solution L could be obtained by adding the heat of dilution D to the latent heat of the pure solvent (water) L_w; $L_l = L_w + D$. Both L_w and D varied with temperature: as regards L_w the values of Henning were reliable: the D variation with temperature must indirectly be deduced, and Porter did this by two methods; (1) From Clapeyron's formula $L_v = T(v - u)\,dP/dt$, where T is the absolute temperature $(v - u)$ the change in volume in evaporating 1 gramme of water from the solution, and P the vapour pressure of the water vapour from the solution. The values generally used for P, *e.g.*, by Lunge in his volumes on Sulphuric Acid, were those of Sorel: Porter preferred those of P. C. Burt, which only covered the range 60 deg. to 100 deg. C., however. Hence he had passed to the second method which required the knowledge of the specific heats of the solution at various strengths. In this deduction he referred to the heat of total evaporation, that is to say, the heat required to evaporate all the water contained in a solution of sulphuric acid: the utility of this quantity, he pointed out, was not impaired by the fact that this total evaporation could, of course, not take place.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Work at the Admiralty collieries has been better this week, and all but a few pits in the Rhondda have been working. The collieries producing inferior qualities have not been so well placed and have been very short of empties, but the position is not nearly so bad as it was a fortnight or three weeks ago. The demand for house and manufacturing coals is good, and there has been an improvement in regard to inland distribution. There is, unfortunately, no appreciable improvement in the supply of pitwood, but the shortage, it is understood, is receiving the close attention of the authorities, and an improvement is anticipated.

Newport.—The demand for Monmouthshire coals for shipment purposes has been slack, and collieries, therefore, are finding it very difficult to keep all their pits at work. The mainstay of those producing the most bituminous descriptions is the inland demand, which continues active.

Pooling of French Coals.—At a meeting of the committee for the supply of coals to France rules were drafted on similar lines to those which apply to the pooling of coals to Italy. These will be submitted to a general meeting of the porters within the next few days, and it is anticipated they will be adopted.

Miners' Christmas Holidays.—It has been agreed by the Welsh Coal Board that the miners be granted three days holidays at Christmas, viz., the Monday, Tuesday and Wednesday. An appeal, however, is made to the men to return to work immediately afterwards, especially at those collieries producing gas coals for which there is just now an urgent demand.

Slack Time in the Coalfield.—No action has yet been taken by the Controller of Coal Mines with the view to an alleviation of the slack time difficulties in the coalfield. The Commission of Inquiry which was recently appointed to deal with the matter has now submitted its report, and, with the Controller's approval, confidential copies of the report and recommendations have been circulated to the members of the Monmouthshire and South Wales Coalowners' Association, and it is considered as likely that action will be taken early in the New Year. It will not, however, be of a drastic character. The recommendations made are rather in the nature of palliatives than in the direction of providing a cure for the evil. It is also regarded as doubtful whether any strong measures intended to give a definite restriction to output with a view to a more general distribution of trade can be adopted without further inquiry and consultation.

Arrears of Contract Issue.—Meetings of coal exporters have been held on the Cardiff Exchange to consider questions relating to the deliveries of contracts entered into prior to June 29 last. It will be recalled that the coalowners and exporters last September failed to agree over the chairmanship of the committee appointed to deal with the matter under the direction of the Coal Controller of August 2 and September 11. At the first meeting Mr. H. J. Hill was appointed chairman on the strength of a majority exporters' vote, but the coalowners' reply insisted that the chairmanship ought to be filled by one of their own number, and when appealed to, the Controller of Coal Mines appointed Mr. Evan Williams as chairman of the Joint Committee for the Cardiff and Swansea districts, and Mr. North Lewis, deputy chairman. The exporters refused to accept these appointments, and at a meeting on September 24 they resigned from the committee. The Controller has since suggested the appointment of an outside person as an independent arbitrator, but at their meeting this week the exporters refused to acquiesce to this proposal and adhered to the position taken up when the original committee was appointed. They are, however, prepared to act on a joint committee without any chairman, but with the Controller's representative on the Coal and Coke Supplies Committee to fall back upon in the event of failure to agree.

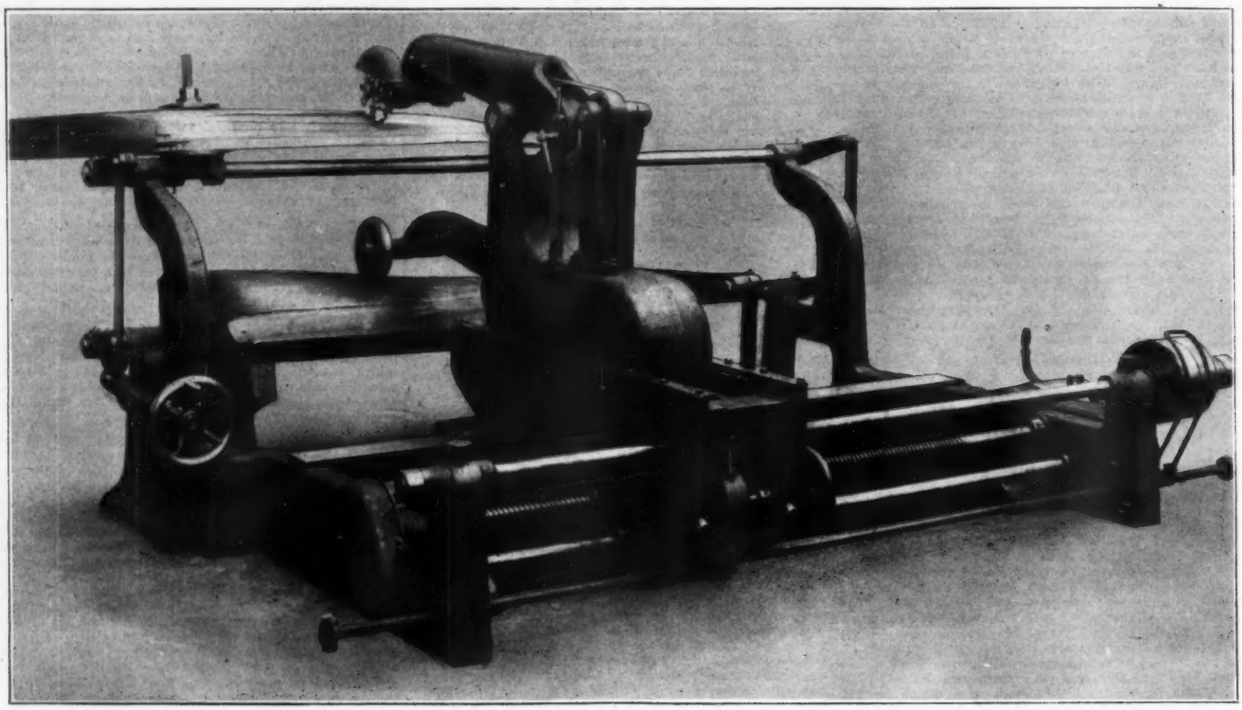
LARGE RIVER INDUSTRIAL UNDERTAKINGS IN NORWAY.—A national steel works in Norway is apparently about to be realised, the Government being ready to assist the undertaking. Narvik, the terminus on the Norwegian coast of the Lapland iron ore railway, is expected to be the site, and iron ore can be drawn from Norwegian and Swedish deposits. The cost of the works is estimated at about £1,250,000 and the profit at £150,000. It is proposed to use Spitzbergen coal, and the number of men is put at 800. An output, when complete of some 250,000 tons per annum is expected. A cement factory is projected at Kjöjisnäs, near Narvik, to give an annual production of 300,000 barrels.

ENGINEERING TRAINING FOR AIR PILOTS.—We are glad to see that the authorities of the East London College are arranging a special course of study for those who are desirous of entering the Government Air Services as pilots. The course is of a comprehensive nature, including aeronautics, aeroplane engines, mechanics, physics, electrical engineering, engineering workshop, together with meteorology. A preliminary knowledge of these subjects is most desirable for those who will eventually become pilots. Taking into account the fact that it is necessary for an airman to enter upon his duties as such when quite a young man, he should obtain at an early age some acquaintance with engineering subjects. Scientific principles cannot be absorbed during a short course of emergency training.

AUTOMATIC AIRPLANE PROPELLER SHAPING MACHINE.

CONSTRUCTED BY MESSRS. WADKIN AND CO., ENGINEERS, LEICESTER.

(*For Description, see Page* 660.)



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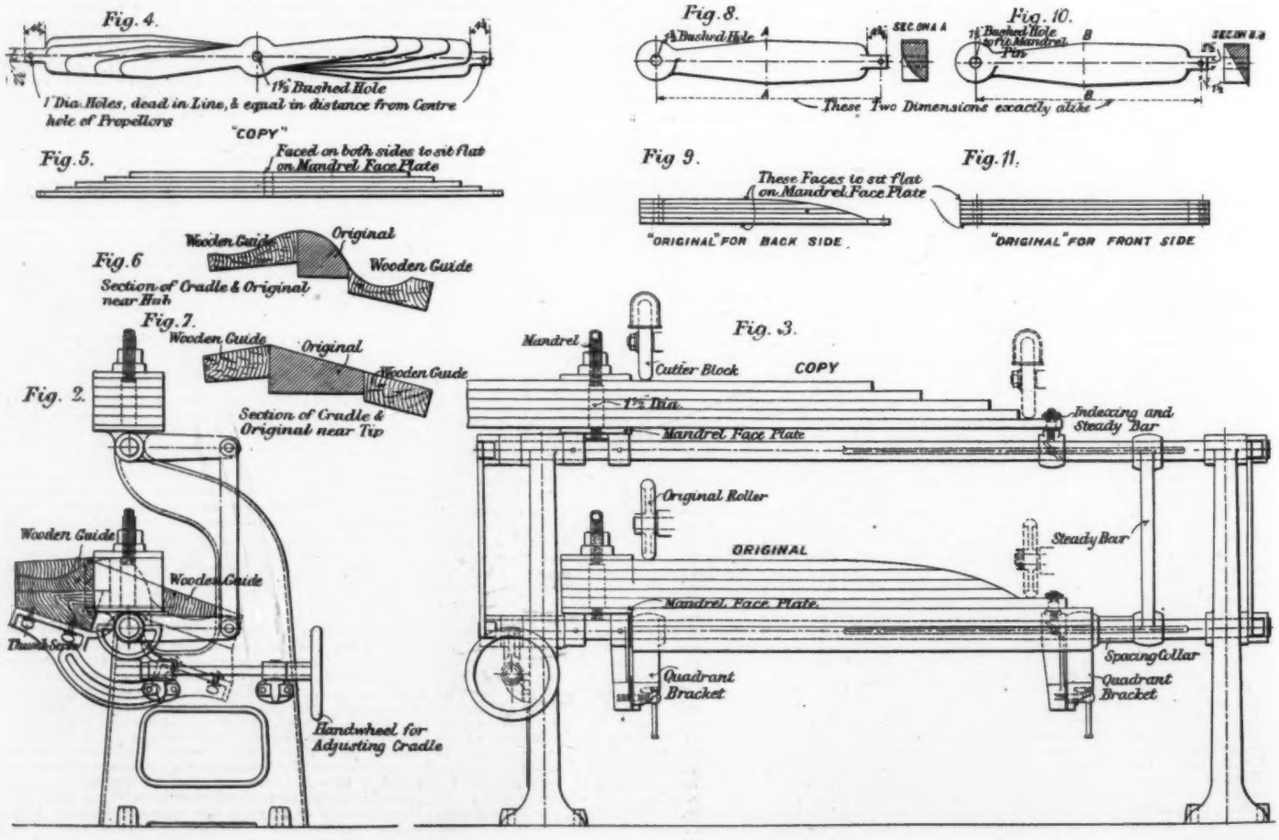


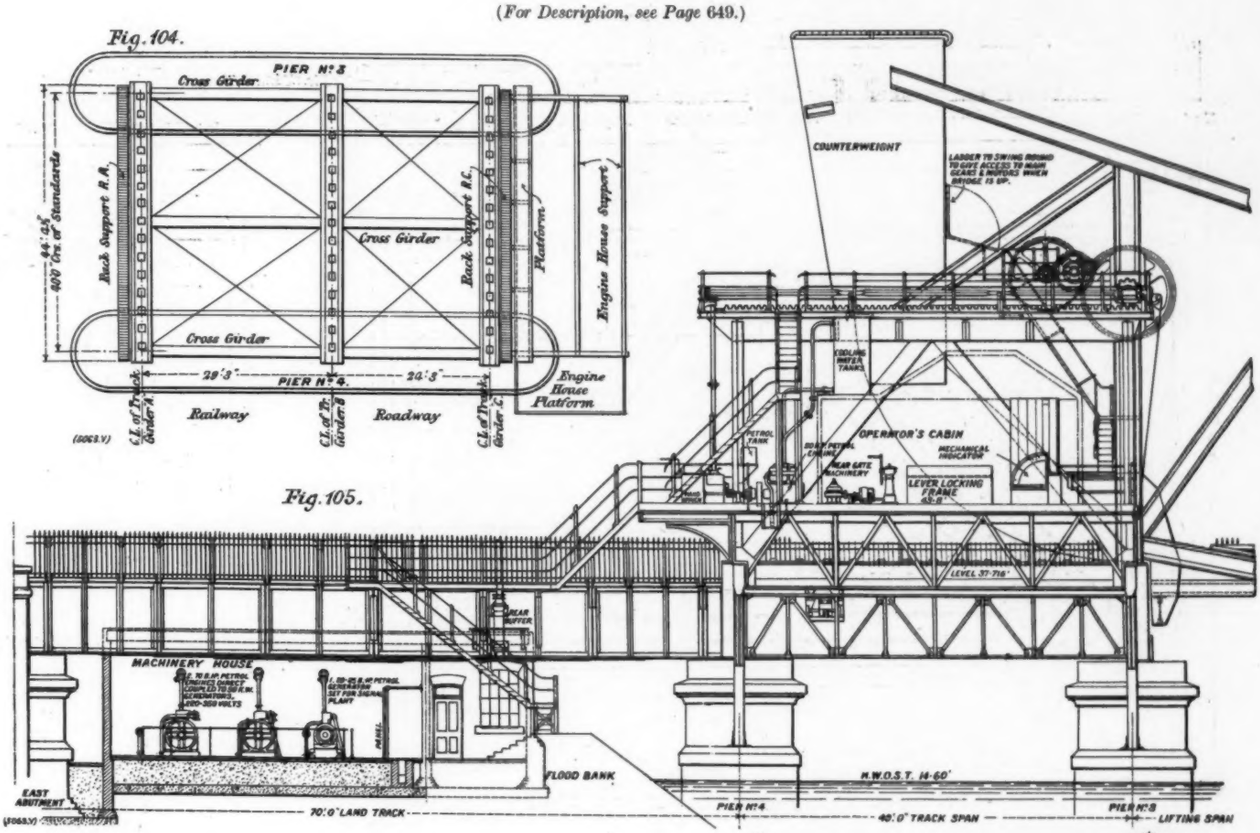
KEADBY BRIDGE; MECHANISM FOR OPERATING SCHERZER ROLLING LIFT SPAN.

MR. J. B. BALL, M. INST. C.E., ENGINEER.

(*For Description, see Page 649.*)

Fig. 104.

Fig. 105.



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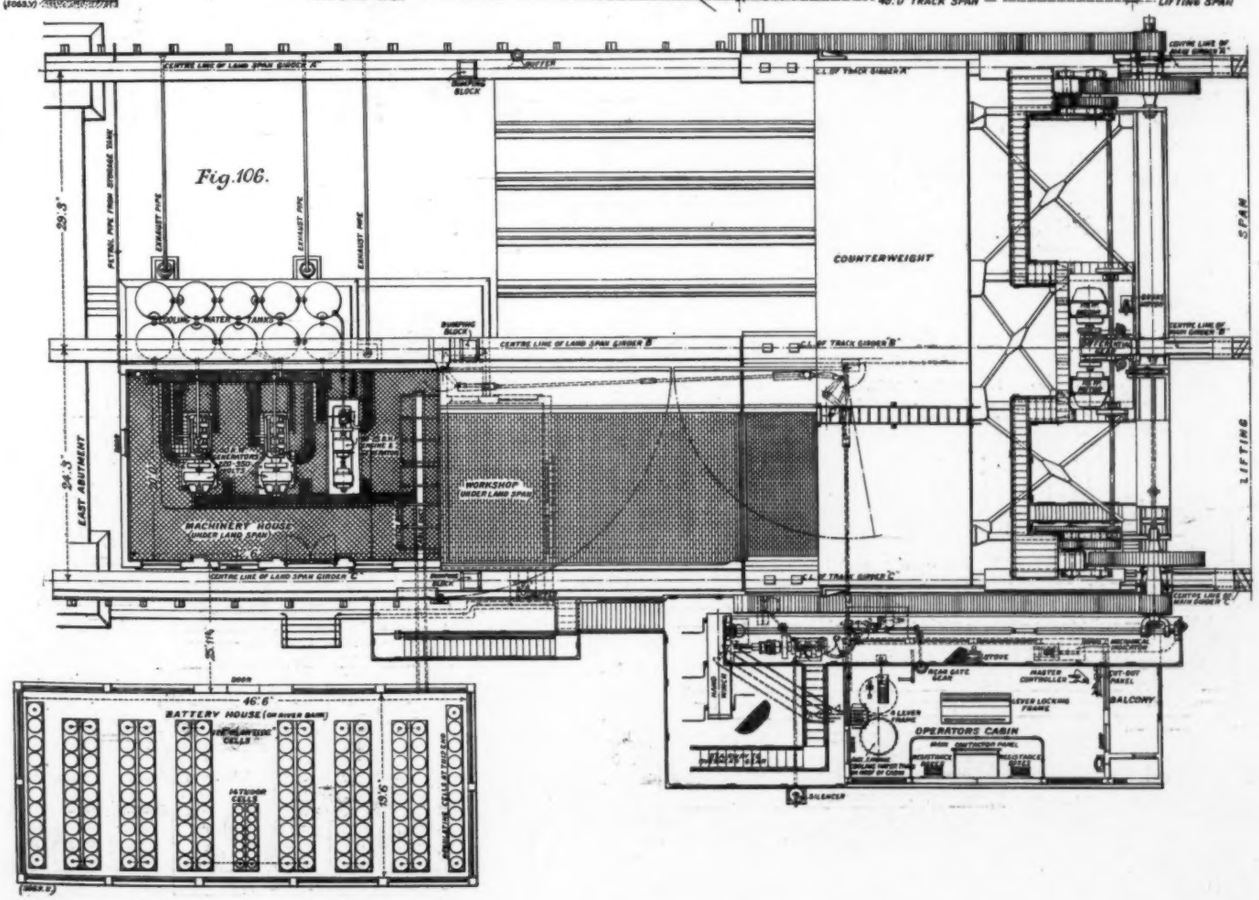


(*To face page 650.*)

KEADBY BRIDGE; MECHANISM FOR OPERATING SCHERZER ROLLING LIFT SPAN.

MR. J. B. BALL, M. INST. C.E., ENGINEER.

(For Description, see Page 649.)

Fig. 107.

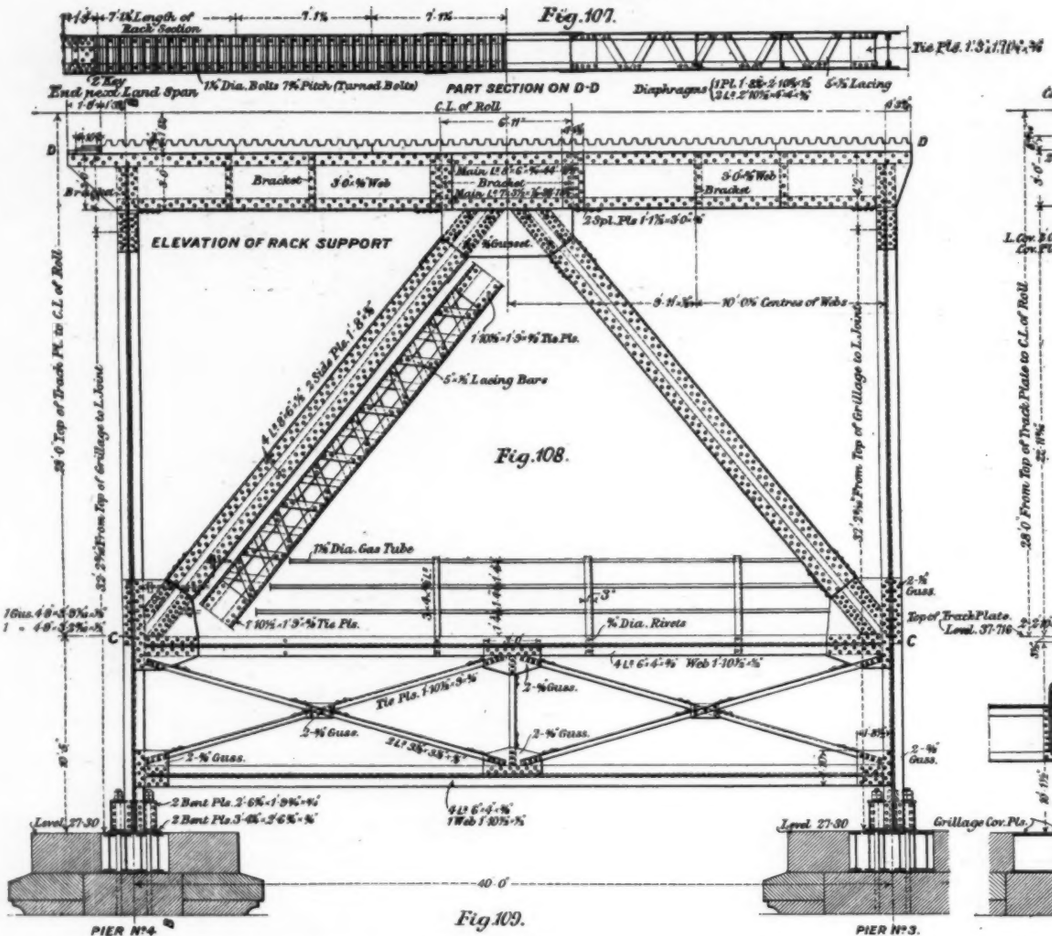


Fig. 110.

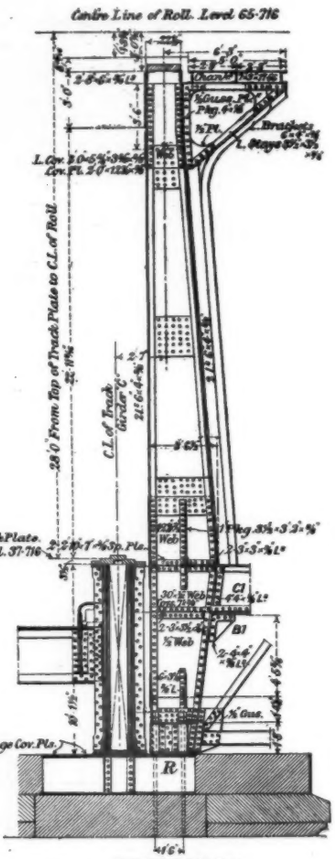


Fig. 111. FOOT OF RACK SUPPORT, (at R Fig 110)

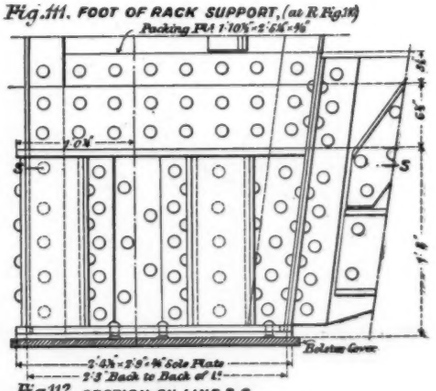


Fig 112. SECTION ON LINE S.S.

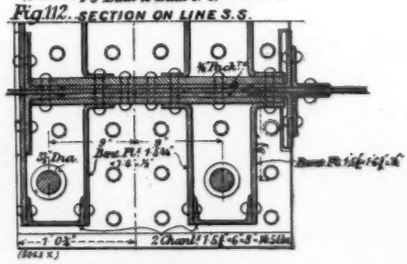
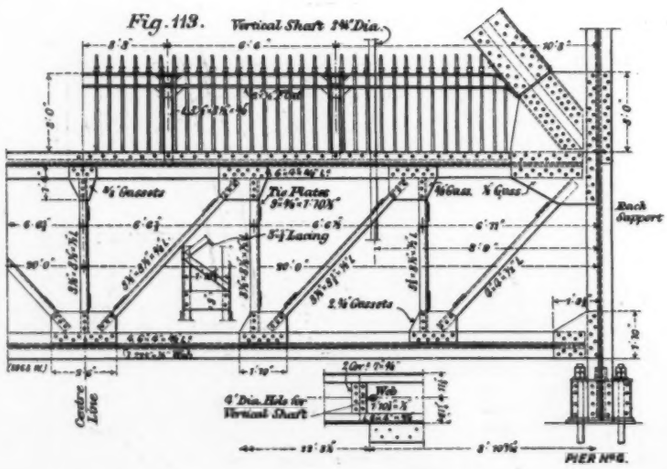


Fig. 113. Vertical Shaft 2¾" Dia.

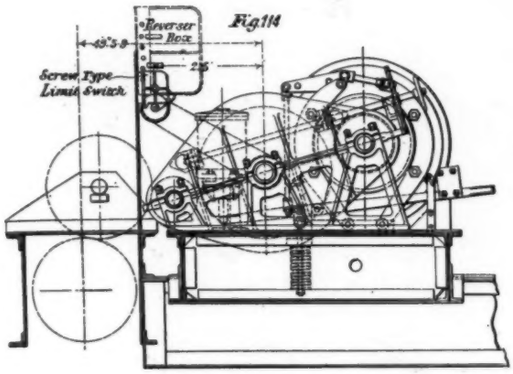


KEADBY BRIDGE; MECHANISM FOR OPERATING SCHERZER ROLLING LIFT SPAN AND SIGNALS.

MR. J. B. BALL, M. INST. C.E., ENGINEER.

(*For Description, see Page 649.*)

Fig. 114.



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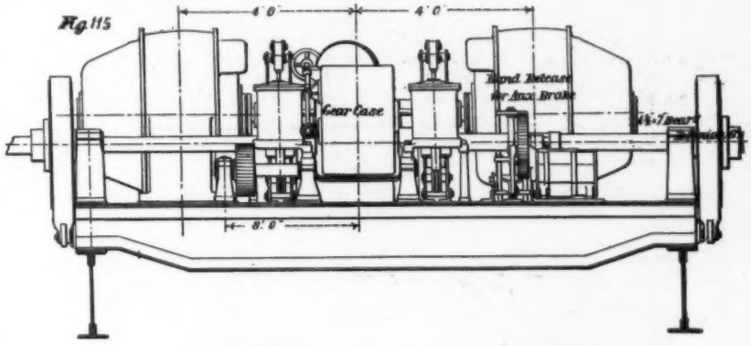


Fig. 116.

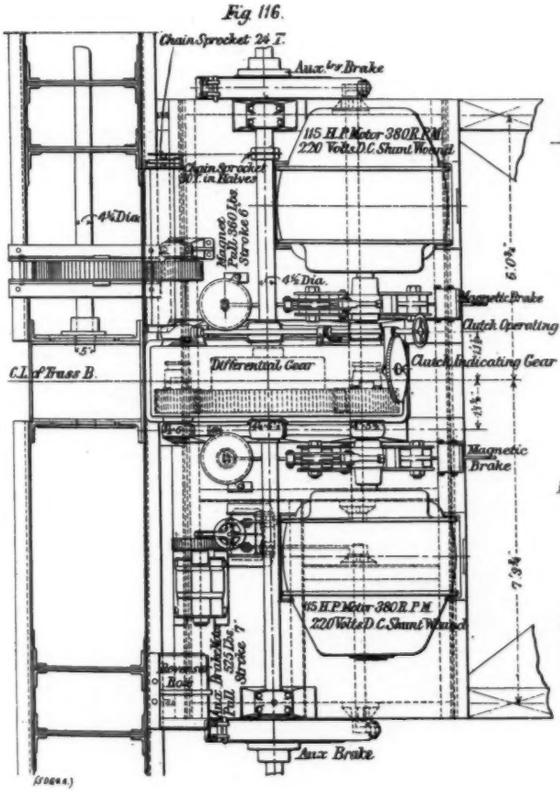

Chain Sprocket 24 T.
Aux. Br. Brake
115 H.P. Motor 380 R.P.M. 220 Volts D.C. Shunt Wound
Chain Sprocket 30 T. in Halves
Magnetic Brake
Clutch Operating Gear
Clutch Indicating Gear
Differential Gear
C.L. of Truss B.
Magnetic Brake
115 H.P. Motor 380 R.P.M. 220 Volts D.C. Shunt Wound
Aux. Brake

Fig. 117.

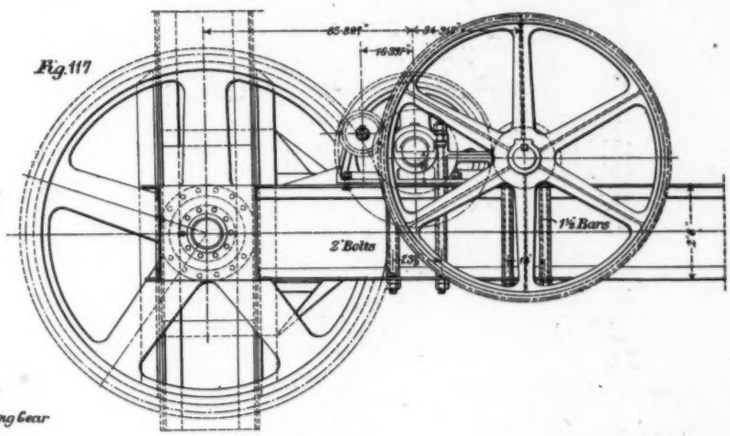
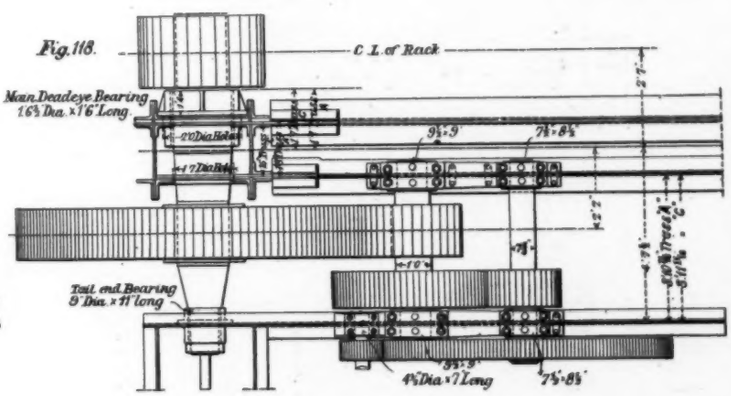


Fig. 118.

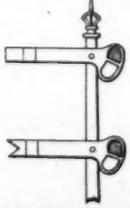


THREE-POSITION SIGNAL.

Fig. 119. DANGER. STOP.

BY DAY, ARM HORIZONTAL.
BY NIGHT, A RED LIGHT.

ORDINARY MECHANICAL SEMAPHORE SIGNALS.



BY DAY, BOTH ARMS HORIZONTAL
BY NIGHT, TWO RED LIGHTS

Fig. 120. CAUTION. PROCEED CAUTIOUSLY.

BY DAY { ARM RAISED TO A POSITION MIDWAY BETWEEN HORIZONTAL & VERTICAL.
BY NIGHT A YELLOW LIGHT

BY DAY { TOP ARM LOWERED. BOTTOM ARM HORIZONTAL.
BY NIGHT { TOP LIGHT GREEN. BOTTOM LIGHT RED

THREE POSITION SIGNAL

Fig. 121. ALL RIGHT. PROCEED

BY DAY, ARM RAISED TO VERTICAL POSITION.
BY NIGHT, A GREEN LIGHT.

ORDINARY MECHANICAL SEMAPHORE SIGNALS.

BY DAY, BOTH ARMS LOWERED
BY NIGHT, A GREEN LIGHT.

KEADBY BRIDGE; MECHANISM FOR OPERATING SCHERZER ROLLING LIFT SPAN AND SIGNALS.

MR. J. B. BALL, M. INST. C.E., ENGINEER.

(*For Description, see Page* 649.)

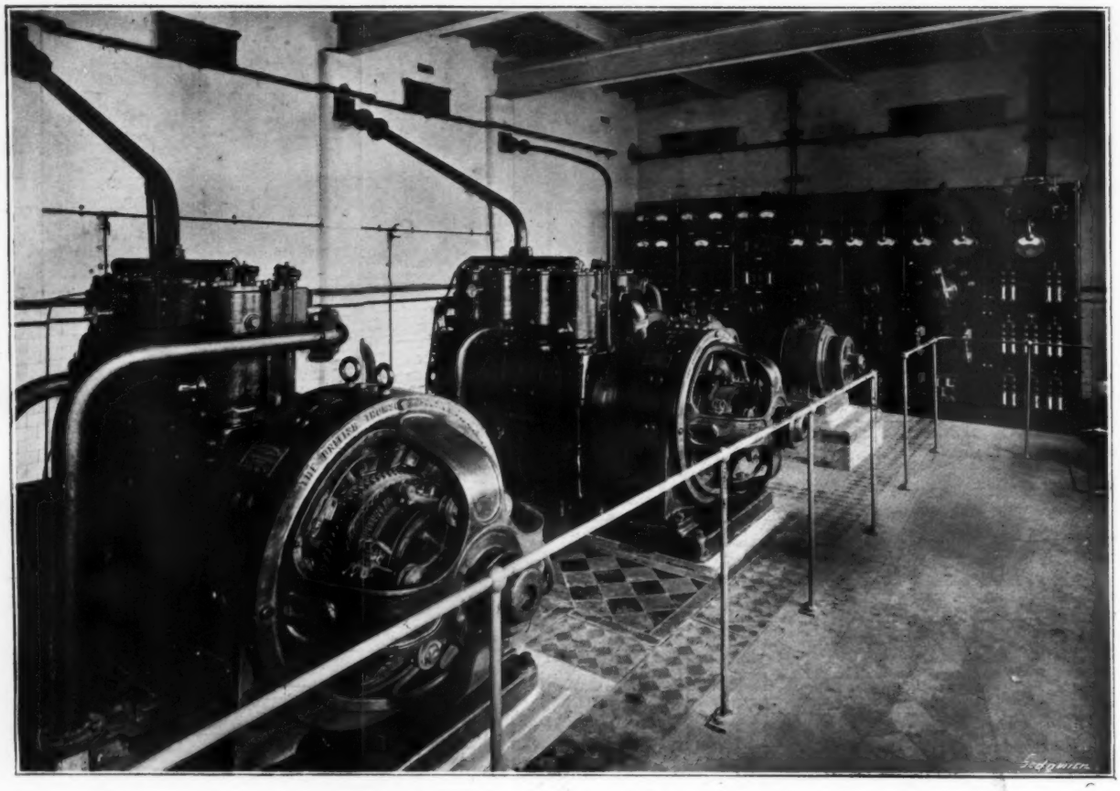


FIG. 122. INTERIOR OF POWER HOUSE UNDER LAND SPAN.

FIG. 123. INTERIOR OF OPERATORS' CABIN SHOWING SIGNALLING LEVER FRAME.

(*To face page* 651.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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NOTICES OF MEETINGS.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, December 21, at 7 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Westgate Road, Newcastle-on-Tyne. The following paper will be read and discussed:—"Some Insufficiently Considered Details of Ship Construction and Equipment," by Mr. C. Waldie Cairns, M.Sc., Member.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, December 21, at 8 p.m., at 39, Victoria Street, Westminster, S.W. Paper to be read:—"Some Out-of-the-Way Engineering Jobs," by Mr. R. H. Parsons.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Thursday, December 27, and Saturday, December 29, at 3 p.m. Christmas Lectures:—"Our Useful Servants: Magnetism and Electricity," will be delivered by Professor J. A. Fleming, D.Sc., F.R.S., M.R.I. Adapted to a juvenile auditory. (1) "Magnets and the Magnetic Compass;" (2) "Electricity and Electric Currents."

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, DECEMBER 21, 1917.

"VICTORY A QUESTION OF TONNAGE."

THE Prime Minister, in his speech at Gray's Inn, said that "victory is now a question of tonnage, and tonnage is victory." The truth of this dictum was found in the announcement since made of the loss in one day of fourteen vessels in the North Sea, most of them belonging to a convoy, and largely owing to the "unexplained" absence of supporting British war vessels of adequate power, which had been arranged for. An inquiry is being held, and therefore nothing further can be said of this episode beyond an expression of keen regret. But it is pertinent to consider whether all that can be done is being done to achieve that measure of victory which is possible by the provision of tonnage. The only light on the subject is that provided in the statement to Parliament by the First Lord of the Admiralty on the 13th inst. So far as it goes it is satisfactory, but it does not go quite far enough, and the information given ought to have been made public a month or two ago, as it would have enabled such criticism of the merchant shipbuilding policy of the Admiralty as is desirable, to be made with intelligent conception of the aims, if not of the actions, of the department of the Deputy Controller of Auxiliary Ship Construction.

Even with such information as is now available criticism is a difficulty. Prudence prohibited Sir Eric Geddes from saying anything as to our warship work. He was justified in his plea that anti-submarine craft must come first, but we are left to assume that the best is being made of existing vessels of this type in all the navies of the Allies. No sentiment, no false pride, must stand in the way of realising the greatest degree of preponderance of naval power possible for the Allies by the absorption into our fleet, from Allies' fleets, of every available ship from the capital ship to the smallest of craft. If by this means it becomes possible to reduce the output of new warships "victory by tonnage" will be assisted. An assurance that this is being done would be advantageous. Again, it would be well to know officially that no warships, not of immediate utility, were absorbing the work of men who could better be employed on merchant vessels. A further point on which there is room for a statement is as to whether ships, long since begun and held up except for the occasional use of men not continuously required on standard or government ships, would not, if rushed to completion, serve effectively to increase our tonnage now, and thus justify the employment on them of man-power. These are pertinent questions, and are not prompted by what Dr. Macnamara petulently referred to as a "nagging" spirit. Such petulence as he displayed in the debate is not worthy of the traditions of the Navy or the Admiralty.

We come now to the information actually given. Much credit is ceded for the centralisation of control, and consequent co-ordination of effort, in connection with ship repair. The Government returns show that since the beginning of March (42 weeks) 1,535 merchant vessels have been "unsuccessfully attacked" by submarine boats. A great majority of these ships were no doubt damaged. Their repair involved less man-power than the building of new ships of corresponding tonnage. This fact is now fully realised. In June, only 27 per cent. of the total salved tonnage was on hand in repairing establishments or docks. To-day 80 per cent. is in hand. The dry dock accommodation of the United Kingdom is now being used 94 per cent. of its time. As for new construction, Sir Eric Geddes took as a measure of the maximum shipbuilding facilities the maximum pre-war output—that of 1913. Lloyd's figures showed for the year an output in vessels, over 100 tons, of 1,932,153 gross register tons of merchant vessels, and 187,566 displacement tons of warships. Sir Eric's figures are 1,920,000 tons of merchantmen, and 181,000 tons of warships; the difference is immaterial. He reckons each displacement ton of warships as equal to two gross tons of merchantmen, with the view obviously of fairly comparing the output now with 1913, without disclosing the warship tonnage output, and he states that on this basis the total output of tonnage—merchant and naval—in 1917, equals that of 1913—his figures being 2,280,000 tons. He did not give the separate merchant ship tonnage output for 1917. What is clear and satisfactory is that the production of merchant shipping during the past three months has been at the same rate as the mercantile shipping in 1913—1,920,000 tons per annum, or 160,000 tons per month. This is so far satisfactory, but much more should be possible because now there is the added stimulus due to the fact that "tonnage is victory."

How can this stimulous be communicated to the workers? We are glad the steel supply shortage has been overcome. This was a serious hindrance to the conception by shipyard workers of the vital need for maximum effort. How could they be persuaded to do their best when they were held up occasionally for want of steel on work of urgency? It is equally important that there should be no similar check owing to delays in issuing detailed plans from the Admiralty department. We are glad to note that 45 new berths have been authorised at existing private yards, and that other proposals are under consideration. This is a move in the right direction and everything should be done to supply the accession to the number of workers in such yards, as by this means fuller use is attainable of furnaces, bending slabs, machine tools and the organisation and staff of such works. Nor should berths ever be left vacant for a day. The fixing of a date for the launch of a ship should coincide with the reception of material for a successor on the slip so that the units can be prepared to be erected as soon as new keel blocks can be laid, and men kept continuously at work on the slip. Only in this way can efficiency be obtained and systematised continuity in organisation be realised. In the great majority of yards this should be more easily realised with standardised ships. That is as great a reason for commendation of the system as the regularisation of steel rolling mill work. Nor is this "nagging," for we have heard too often of empty berths in shipbuilding works.

Another proposal which has militated against stimulating workers to maximum effort is the proposal for national yards. Mr. Wilkie, himself a shipwright, condemned the procedure on the grounds that we have time and again put forward. "Highly skilled men could not be got for the new yards at present without depleting staffs engaged on work which was vital for carrying on the war." Moreover, the effort put forth in organising and equipping these new works could better be utilised immediately in existing yards. Although the project was conceived

some months ago, the first keel will not be laid until next month, if then, and the first vessel completed a year hence. The three national yards —all on the River Severn—will have 34 berths, and the cost, "including hutting accommodation," is estimated at £3,887,000. Even if this is not exceeded, this equals £114,300 per berth, which is much more than the cost of an equal number of berths added to existing yards. We are now told that these yards, or at least two of them, are to be utilised for the construction of more highly standardised ships. Thus only in one of the yards is it proposed to put any large amount of manufacturing plant. The others are to have the manufacturing work done in bridge yards—the limit to the size of units being the largest dimensions which the railways can carry without impeding other traffic. The idea is being carried out in the United States, and special interest attaches to the paper which we reproduce in another part of this issue describing such ships which are known in the States as "fabricated" ships. It is contended that the location of the national yards on the Severn would enable South Wales steel to be used. But that can only reduce railway haulage if the large bridge builders are also located in South Wales. Is this the case? Again, obviously, German prisoners of war are to be utilised for erectional work. But could these not be drafted to some of the existing yards? We have seen German prisoners in private works of a kindred nation. But Sir Eric has given the assurance that the existing yards will have priority in the supply of labour as of material, and if there is never in a yard in the future an empty berth or a check to progress, due to the Admiralty department, good will accrue, as it will lend great support to the plea that the best is required from every ship-yard worker, since "tonnage is victory."

SCIENTIFIC MANAGEMENT.

Scientific management is popularly supposed to be an American system, and it has needed a gigantic war to secure for it fair consideration in this country. It would have received a better welcome if it had been understood that it was merely a development of a British system. Our insular prejudices would not then have bristled so fiercely at its mention, although trade union opposition would probably have been no less strenuous. The fact is that nearly every really successful business is built up by scientific management in one department or another, either in buying, selling, or manufacturing. Generally, it must be confessed, in one of the two former, since the train of agencies is much shorter in commercial matters than in those of the workshop. Buying and selling do not involve a very lengthy series of operations and the head of the department can keep control of the entire chain with a fair amount of certainty. We do not suggest that the commercial side of business needs less ability than the manufacturing side, but given the ability, there is certainly far less friction and inertia in the office than in the workshop.

Scientific management is really intensive thinking. It means that every problem shall be solved intellectually and not by a system of trial and error. It involves the separation, to a very large extent, of the mental and mechanical sides of a business, and is by no means confined to engineering matters. We have long been accustomed to it in large retail shops, where the idea of each salesman being a specialist has been abandoned, and where there is now one well paid man in each department, and a large number of assistants of very scanty knowledge. Every article is marked in plain figures, and all that the counterman has to do is to hand them over and make out the bill. The payment takes place at a separate desk and is received by a girl who simply has to make her cash balance against the entries in her book. Matters can never be so simple as this in a manufacturing establishment, but success is found by following the same lines. The essential thing is that no work shall be sent into the shops as long as any doubt exists as to how it shall be executed. Foremen and workmen always find a way of doing the most awkward job, but they do so at an excessive cost, and in the case of repetition work this cost is repeated many times. Even if there be no particular difficulty to be faced the foreman cannot tell how much he is justified in spending on special fittings unless he is told what are the prospects of the job being repeated again and again. Indeed, unless he knows that costs are watched with a very jealous eye, he is likely to leave the whole matter to the workman, who has—or thinks he has—no interest in economy.

Scientific management does not demand an equipment of modern tools, although it bears its most abundant harvest in a shop fitted with the best plant for repetition work. Its location lies in the offices, and particularly in the drawing office. In many places it is the adaptation of design to the available tools that is the evidence of scientific thought, while in others it is the preparation of jigs and tools in advance that marks the full appreciation of the possibilities of economic working. In both cases there is evidence that the designer or the manager has projected his mind forward through the series of operations to be performed, and has satisfied himself that he has made the best use of the means at his disposal.

We have said that scientific management implies intensive thinking, and we may add to this that a large percentage of mankind not only hates such a practice, but is quite incapable of carrying it on. If one brain could cover all the operations in a works it would not be difficult to find the single man needed. But the processes of manufacture are far too numerous and detailed for that to be possible. Hence we are met with the inquiry as to how the men are to be found to carry out the system. This matter was referred to in an admirable paper read last Tuesday by Mr. James Richardson before the Institution of Engineers and Shipbuilders in Scotland, a paper which we reproduce in this issue. Mr. Richardson said that the demand would produce the supply, a point on which he is well entitled to speak, as he is a young man himself and, holding a highly responsible position, he must already have found by experience whether he can procure the assistance he needs. From this point of view scientific management ought to be received kindly by the younger and more ambitious members of the working classes. It must be admitted that of recent years the outlook of the workman has become somewhat hopeless; it has grown more and more difficult to escape from the condition of life in which chance had placed him. But scientific management multiplies the proportion of black coats to overalls, by two or three, or even four, and there is no reason why the workman should not aspire to the offices so created. It is quite certain that scientific management can only be run by those with workshop experience, and it is from the younger men who have taken advantage of the increased educational opportunities of the present day that the new posts must be filled.

Mr. Richardson utters a note of warning against a hurried attempt at the introduction of scientific management. As the system itself involves continuous and hard thinking, so its commencement must be preceded by the laying of accurate plans. Scientific management does not consist in supplying all the foremen with stop watches and by forcing the pace of the worker. It must commence at the top, and the early stages may well be completed before any rumour of it reaches the shops. It would be most interesting to have a detailed account of the changes made in this way in some important establishment. Much that has been written deals with generalities, and Mr. Richardson explained in his paper that he was confining himself to principles. Naturally these come first, but it is a great aid to comprehension if the study of a good example can be given in detail. Possibly Mr. Richardson could do this in a subsequent paper, and thus add to the benefit he has conferred on the industry. It is quite certain peace will find us not fully prepared for the opportunities it will bring. One reason, of course, is that all our energies are now concentrated on winning the war, and that those who are really competent to introduce new methods are fully occupied. Another is that committees, of which we have more than enough, have a great attraction for the type of man who delights in generalities and who never gets beyond them. There is nothing really constructive in his criticisms. Mr. Richardson said: "Industrialism is in the melting-pot, and the present gives us an unparalleled opportunity to mould it afresh;" therefore it is quite time that the patterns for the mould should be got out, so that the metal may be teemed as soon as the war is over. The essence of scientific management lies in taking long views, and it is quite time that the leading spirits in every works should apply themselves to the problems that lie ahead of them. It is not necessary to wait for peace for the initial steps. A beginning can be made at once, and the sooner the better.

AIR PUMPS AND CONDENSERS.

The advantage of using steam jets in series with an ordinary reciprocating air pump has long been recognised in power station practice, where, since the advent of the turbine, the desideratum has been the maintenance of the highest possible vacuum consistent with the available supply of cooling water. No doubt, by the exercise of extreme care, in reducing to a minimum all air leakage, even that through mere pin holes, nearly as good results can be obtained without a steam jet as with it, provided, of course, that the steam plant is of the turbine type. The maintenance of this exceptionally high standard of air tightness demands, however, such constant vigilance on the part of the station staff, as to have made most engineers consider it preferable to instal the steam jet, with which high vacuum can be secured without the necessity of such exceptional and unceasing care.

Of course, in the case of a reciprocator the permanent maintenance of a really high vacuum is almost impracticable without the use of the jet, but admittedly, the disadvantages attaching to a poor vacuum are also less serious than they are when steam turbines constitute the power plant. This arises because the reciprocating engine is incapable of utilising the "toe of the diagram." In fact, the recognised standard vacuum in the case of Lancashire mill engines tends, in practice, to be rather below than above 24 in., and whilst a 28 in. vacuum is not infrequently specified for cargo boat engines on trial, few sea-going engineers attempt to maintain this standard in actual service, where such a figure as 25 in. is by no means uncommon.

A new application of the steam jet to vacuum production has recently been suggested by Mr. D. B. Morison. As the result of an extended investigation, he has been brought to the conclusion that great as is the value of the steam jet for the production of a good vacuum, it has at least equal advantages when the conditions are such that a poor vacuum meets the needs of the case. From Mr. Morison's experiments it appears that if a 25 in. or 26 in. vacuum will satisfy requirements, this can be obtained more cheaply and maintained more certainly by the use of auxiliary steam jets than in any other way.

A bad vacuum in a condenser, if not due to dirty tubes or hot cooling water, implies that much of the tubing is air jacketted and correspondingly inefficient. With a clean condenser, and with an air leakage reduced to a minimum, the rate of heat transfer may approach the figure of 1,000 B.Th.U. per square foot of cooling surface per hour and per degree of temperature difference between the steam and the cooling water. Indeed, under experimental conditions, this figure may be very materially increased. No very large amount of air leakage will, however, suffice to reduce the rate of heat flow from steam to cooling water by 60 per cent. to 70 per cent.

It is impracticable in the commercial operation of reciprocating engines to prevent air leakage, and as a consequence much of the tubing in the condenser becomes seriously ineffective. The rate of heat flow is no doubt satisfactory in the case of the upper nests of tubing, which receive the first rush of the steam. As the steam enters the condenser the proportion of air to steam is small, but as the mixture of gas and vapour passes on towards the air pump inlet this proportion becomes higher and higher, so that the air may ultimately form the preponderating constituent. Air is a most excellent non-conductor. As the mixture passes over the tubes the steam, as it condenses, drops away as water, but the air remains behind, jacketting the tube and hindering the access of further

molecules of steam to the cooling surface. The lower rows of tubes in a reciprocating engine condenser become accordingly singularly ineffective.

The question naturally arises, as to why, this being so, they cannot be abolished, retaining merely the upper and more efficient rows. The answer lies in the fact that the air pumps can only remove a certain volume of air per minute, equal, at best, to their gross piston displacement. The volume of the air to be abstracted depends both on its temperature and pressure. If the lower tubing be removed as suggested, the air will be delivered to the pumps at a higher temperature. Hence, to remove the same weight per minute, either the piston displacement must be increased or the air must be delivered to the pump at a higher pressure which will, of course, involve a worse vacuum in the condenser. Moreover, the higher pressure of the air inside the condenser will render it an even more effective blanket than before. A limit is thus set to the possibility of removing the ineffective tubing.

Here is to be found the advantage of the steam jet. Suppose the lower ineffective tubes to be removed, then, as pointed out, as the air is hotter, it must reach the pump at a higher pressure than

Fig. 1.

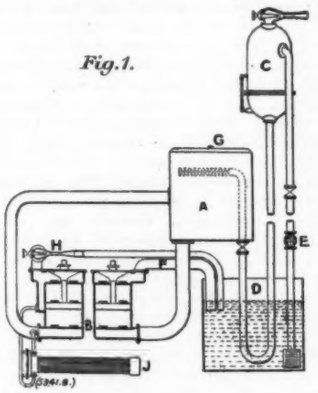
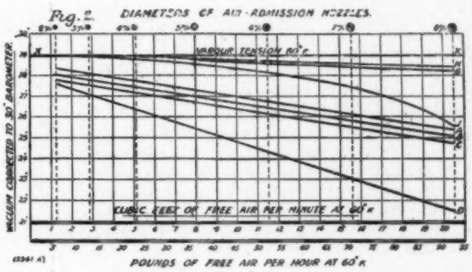


Fig. 2.


DIAMETERS OF AIR-ADMISSION NOZZLES.
VAPOUR TENSION 80°F.
INCHES CONNECTED TO 30" BAROMETER
CUBIC FEET OR FREE AIR PER MINUTE AT 60°F.
POUNDS OF FREE AIR PER HOUR AT 60°F.

before if the weight of it delivered per minute is to remain unchanged. With no aid from steam jets this higher pressure in the pump would involve a worse vacuum in the condenser. By interposing steam jets between the condenser and the pump, these jets, which, as is well known, have a great volumetric capacity, compress the air into the pump suctions, so that a large weight of air can be abstracted with a very moderate pump displacement. The great advantage of this in the present shortage of brass and other copper alloys lies in the fact that the amount of cooling surface in the condenser can be reduced 20 per cent. to 25 per cent. without loss of vacuum, and the air pumps may also be much smaller than is called for in ordinary standard practice. There is thus a direct and material saving in capital costs, and also, of course, in the time needed for constructing the condenser and its auxiliaries. These considerations would, of themselves, be sufficient to justify the extensive adoption of the system at the present crisis. The experiments carried out, with Mr. Morison's plant, on behalf of the North East Coast Institution of Engineers and Shipbuilders* show, however, that over and above the gains under this head the running expenses are actually lower than with the usual system. Thus suppose that with the ordinary system steam-driven air pumps of the best type are used, having say a consumption represented by 100; then, if the Morison system be adopted, allowing the condenser surface to be cut down by 25 per cent., the combined consumption of the air pumps and the jets will be represented by perhaps 80. This way of stating the facts indeed rather underestimates the gain, since it has been found that the jets can be worked perfectly well with exhaust steam from the auxiliaries which would otherwise be for the most part wasted. Moreover, the feed is delivered to the hot well at a higher temperature than would be practicable were it necessary to keep the condenser at a temperature low enough for the air to be dealt with by ordinary air pumps without prior compression by the jets.

The experiments on the Morison apparatus were carried out for the North East Coast Institution by Messrs. E. L. Orde, C. W. Cairns, and Dr. J. Morrow. The plant, which is depicted diagrammatically in Fig. 1, consisted of a receiver A, 4 ft. 3 in. in diameter by 4 ft. high, which represented the condenser, and was built of steel plates. Water drawn up by suction from a tank D, representing the usual hot well was sprayed into this vessel near its top, and was withdrawn at the bottom by the pumps being returned by them to the hot well. As very large quantities of air were delivered with the condensate a de-aerator C was interposed between the hotwell and the receiver, as indicated. A vacuum of 25 in. was maintained in this de-aerator by means of a steam jet. A number of gauged orifices, ranging from 2 mm. to 8 mm. in diameter were fitted, through which air could be admitted to the receiver. The 2 mm. orifice, as indicated in Fig. 2, discharged about 6 lb. of air per hour, and the 8 mm. orifice about 93 lb. of air per hour, a figure which would represent a truly enormous leak. In power station practice, for example, it is recognised that the weight of air entering the condenser per hour should not exceed 4 lb. per 10,000 lb. of feed.

In this figure the line X X shows the vacuum which would have been obtained in the complete absence of air. The upper lines H and G show how closely this ideal limit is approached when steam jets are used to assist the air pumps. The curve H was obtained when the "condensate" was about 10,000 lb. per hour, and G when it was 60,000 lb. per hour. The curves A, B, C, were obtained with the air pumps operating alone, the steam jet and its accessories being removed. The curve J shows the vacuum obtained when the steam jet was used, but the air pump capacity halved. It should be compared with D, which shows the results obtained without the steam jet, but with half the airpump out of action.

The first series of trials were made with ordinary reciprocating air pumps, having two barrels, 20 in. in diameter by 15 in. stroke, and driven by steam. The arrangement was such that both barrels could be worked either on the ordinary wet system, or with one barrel wet and one acting as a dry air pump. In these tests the steam jet apparatus indicated in Fig. 1 was of course out of action. It was found that with the 8 mm. nozzle open a vacuum of 26.2 in. could be maintained with the air pumps acting alone, the steam consumption being 1,420 lb. per hour. Using a steam jet taking 430 lb. of steam per hour, and running the air pumps at such a rate that their consumption was 940 lb. per hour, making a total of 1,370 per hour, the vacuum with the same air orifice open was 28.22 in. Hence the reduction in steam consumption was accompanied by an improvement of 2 in. in the vacuum. If this higher vacuum were not required, the steam consumption could obviously have been still further reduced. In this series of experiments the jets were fed with steam at 70 lb. gauge pressure. In another set of trials steam at a pressure of from 3 lb. to 26 lb. (gauge) pressure was used for the jets. In this case the jets were arranged in series. In the same conditions as already noted above, a vacuum of 27.55 in. was maintained with the 8 mm. orifice open. The total steam consumption for jets and pumps being 1,700 lb. per hour. With the 7 mm. orifice open (which passed in about 71 lb. of air per hour), a vacuum of 26 in. was maintained with a total consumption of 1,320 lb. per hour, of which two-thirds was steam at 30 lb. pressure. The air pumps acting alone consumed under the same conditions 1,420 lb. per hour, the vacuum being 26.65 in. In this case, of course, the whole of the steam used was high pressure steam. In these particular tests the air leakage was abnormally high. With more normal conditions of operation, however, the advantage of the Morison system was still manifest. Thus with the 3 mm. nozzle open, which passed about 13 lb. of air per hour, the air pumps acting alone, consumed 780 lb. of steam per hour in maintaining a vacuum of 27.4 in. With the same air nozzle opening the combination of low pressure jets and air pumps gave a vacuum 28.80 in., with a total consumption of 740 lb. of steam per hour, of which but 280 lb. were used for the pumps. The pressure at the jets in this test was respectively 7 lb. and 9 lb. per in. gauge.

The report will well repay careful study, and affords substantial grounds for anticipating important changes in the construction of condensing plant for cargo steamers.

* First Report to the Council of the North East Coast Institution of Engineers and Shipbuilders on Certain Methods of Producing Vacuum. By Edwin J. Orde, C. Waldie Cairns, M.Sc., J. Morrow, M.Sc., D. Eng. Published by the Institution, Newcastle-on-Tyne. Price, 10s. 6d.

THE PROSPECTIVE OILFIELDS OF BARBADOS.

NEXT to the occurrence of petroleum in the British Isles the question of oilfields in various parts of the British Empire is of the highest interest. When Mr. E. H. Cunningham Craig, B.A., F.R.S.E., F.G.S., brought a communication on "The Prospective Oilfields of Barbados" before the Institution of Petroleum Technologists on December 18, he had unfortunately to admit that he did not suggest the existence of great and prolific oilfields in that island. It is only a few weeks ago that the same institution had been warned against entertaining such hopes for the United Kingdom. There is every probability, however, according to Mr. Cunningham Craig, of moderate oil productions being obtained in Barbados and of establishing a prosperous little industry. Since not much has been done, however, through finds of "green tar" and manjak or munjac flows have been of common occurrence, the paper was largely geological of course.

The three main geological formations of Barbados the lecturer explained, are in ascending order: the Scotland Beds, a litoral, estuarine and deltaic group of strata (probably of tertiary age); the Oceanic Beds (probably miocene); and the Coral Limestone. The island itself lies on the outer rim of the great Caribbean basin. This rim, obviously a recent earthfold of considerable importance, curves round from an offshoot of the Andean chain of Colombia and Venezuela through Trinidad, Tobago and Barbados to Barbuda, a smaller island a long way further off, and on through Anguilla and the Virgin Islands to Porto Rico, San Domingo and Cuba. Within this outer ring (comprising the Windward Islands mentioned) comes the inner volcanic ring of Leeward Islands, from Santa Margarita through Grenada, St. Vincent (78 miles west of Barbados, which is the outermost of the islands), St. Lucia to St. Kitts. Chains of deep and shallow soundings emphasise the concentric arrangement of earthfolds. In Trinidad the main lines of folding, west-east in Venezuela, already run slightly to the north; in Barbados the general pitch of the folding is more south-westerly. Simultaneous with the earliest folding of the Scotland Beds the whole area begun to sink in the trough of a great earth-wave, the crest of which a little further west probably reached the water surface; there the volcanicity, which is still in evidence on St. Vincent

and Martinique, had commenced, and fine volcanic ashes mingle with the oceanic beds of Barbados. Later the outer rim began to rise, folding the oceanic beds, while the land surfaces to the east and south of Barbados disappeared. Barbados was born as a coral reef, and rose in successive stages, each marked by a horizontal coral terrace, until it reached its actual maximum level in Hillaby Mount (1,105 ft. high); the movement is possibly still proceeding. The fragmentary paragraphs of earth-history, Mr. Cunningham Craig remarked in concluding this section of his paper, might have remained untranslatable, had not Barbados furnished the key to Nature's cryptogram. Yet, to apply this knowledge to the practical question of oilfield development in Barbados was by no means so simple as in most oilfields.

Wherever the Scotland Beds were exposed, there were traces of petroleum; there were many good seepages of heavy oil, innumerable outcrops of oil-sand, in two or three localities manjak veins gave evidence of petroleum at greater depths, and there was one natural gas well, the long known "Boiling Spring." But the Scotland Beds presented no broad, well-defined anticlines for testing; the folding was sharp and irregular, the dips were steep, and though the upper layers were largely argillaceous, they had frequently been denuded, and could not have sealed up petroleum, except in a very minute and local manner. Practically all the attempts to win oil had been made in the vicinity of outcrops of oil and where the petroliferous beds were fully exposed; an asphaltic oil, heavy or light, had been obtained in all those cases, but the yield had soon fallen off to an unremunerative total, and though Mr. Craig believed that one or two wells were now being pumped occasionally, the production of oil was negligible. The later or post-oceanic flexures were of greater importance in this connection than the earlier folding. This folding was broader and more gentle, moreover, and these flexures had to be studied beneath the capping of coral which wiped out all evidence of older rocks. So far there were no deep-drilled wells, however, to guide the prospector. But there were several small prospecting areas; the report on the oil survey had been published, though the 6-in. maps were not out yet.

Much credit was due to the efforts of the Hon. A. C. Ponsonby to found a petroleum industry in Barbados. Fourteen wells had been drilled, though not all to sufficient depths, in addition to shallow prospecting wells. The chief area was at Turner's Hall, the eight wells of which were rather close to one another, unfortunately; the best year's production from all these wells averaged two barrels per well per day. It was a fairly high-grade petroleum of asphaltic base, mobile and containing a good percentage of light oil. As the geological conditions at Turner's Hall were not favourable, better results might be obtained in more carefully-selected areas. The great obstacle to the development was, however, the difficulty of securing rights to prospect over large areas. The island was all freehold property, divided into a very large number of small estates, all carrying full mineral rights. Every attempt made to induce a number of proprietors to combine had failed. Legislation had been resorted to, but various Acts had been unable to stimulate development. A monopoly granted to a group of capitalists to prospect, and to win, transport and refine oil, might answer; but there was no likelihood of that method being adopted. There might also be a monopoly for pipe-lining and refining, each proprietor making his own arrangements for developing his land; no one liked the sound of the word monopoly, however. Even the most hopeful proposal by Sir Leslie Probyn, to make each of the 11 parishes of the island a separate area, with trustees to safeguard the interests of the proprietors in the areas, had not passed the Legislative Council. Thus one of the oldest Colonial possessions, and the second one to obtain representative government, a colony with an intelligent population, excellent overland water supply, a healthy climate, cheap labour [about 10 per cent. of the inhabitants are white, we believe], was failing to develop a natural asset, probably valuable. "It is here that the voice of the Empire should be heard in no uncertain tones," Mr. Cunningham Craig said. In an Imperial co-operation each British oilfield's duty and right would be to deliver, according to its ability, so much petrol, so much lubricating oil, so much oil fuel for the needs of the Empire. Every British country should be assessed upon its possible output, and directed to deliver or keep in storage the quantity of oil of the required specification for imperial needs, not only for peace-time consumption, but also for provision against any future war in which the Empire might be involved.

Mr. Cunningham Craig might have given a few general notes concerning the island he lectured on, in explanation of the little industry he spoke of. The British sailors who first settled on the island in 1625, found it densely wooded and uninhabited. Now Barbados is situated in the track of shipping, and a well-to-do population of nearly 200,000 inhabitants is spread over an island of 166 sq. miles (one-tenth the size of Trinidad), about as big as the Isle of Wight; if Greater London were confined to the area of a circle of seven miles' radius, described about Charing Cross as centre, the area of Barbados could nearly be accommodated within that circle—sufficient an area for the growth of an industry of local importance, at any rate.

NOTES.

The Lubrication of Air Compressors.

In a paper read before the Diesel Engine Users' Association last November, Mr. Geo. W. F. Horner described some troublesome experiences with Diesel engine compressors. The compressor was of the three-stage type, and up till the end of 1915, ran satisfactorily, but it then became difficult to keep the H.P. cylinder tight. The lubricant was accordingly changed, and the trouble ceased for six months, when it reappeared, and a further change of lubricant was decided on, a good class mineral oil of Pennsylvanian origin being adopted, having the following characteristics:—Viscosity at 100 deg. F., 286 seconds; at 140 deg. F., 200 seconds; at 212 deg. F., 52 seconds. The vapourising point was 350 deg. F.; the flash-point (open test) 425 deg. F.; and the ignition point 505 deg. F. The oil was free from acidity, but acted as a purge on the deposits left by the oils previously used. After using this oil for some time, a brownish substance was found mixed with the oil in the I.P. purge pot. This was carried forward to the H.P. cylinder and caked on the valves and pistons, causing such excessive wear that it was necessary to change the rings and valves every few days. Analysis showed that the deposit was largely oxide of iron, and the trouble was cured by painting the interior of the purge pots with a rust and acid-proof paint. In the case of another compressor without purge pots, which was also giving trouble, all the accessible surfaces in contact with the air were similarly treated, and with a consequent decided improvement in the working results.

Cannonades and Rainfall.

The idea that great battles are followed by heavy rainfalls is far older than gunpowder. What Pliny ascribed partly to the kind intention of the gods to purify the air, vitiated materially and ethically by the devastation and slaughter, and partly to the exhalations from the blood shed and from the putrifying corpses, modern writers attribute to the violent concussions of the atmosphere, produced by the bombardments, and to the immense clouds of dust which our guns directly send into the air together with the explosion from gases, and indirectly stir up from the ground. It is only natural that the people should connect the heavy and persistent rains of the war years with the terrific cannonades, compared with which the great historic bombardments were mere toy displays. When we look into the probability of the suggested correlation, however, we recognise that the question remains theoretically open, and that the statistics may as usual be interpreted in various ways. When weather shooting was taken up seriously, about twenty years ago, in certain districts of the Continent and America, it was done mainly for the purpose of protecting the vineyards from the hail, which is much more dreaded on the Continent than in the British Isles. The special mortars were pointed upward so as to send smoke rings in lively gyration up into the threatening clouds, to disperse them or to hasten the vapour condensation by the agitation of the air. This was done on favourite thunderstorm tracks; the hail-shooting had its vogue and fell into disuse again. When in September, 1915, a spell of fine weather came to an abrupt end with the French offensive in the Champagne, the incessant downpour was attributed to the incessant cannonade, and stress was laid upon the clouds of water-vapour and the enormous numbers of condensation nuclei which the explosion gases are supposed to carry. It is easy to demonstrate that air laden with moisture will hardly condense in the absence of all dust or condensation nuclei. Up till recent years all dust particles were considered more or less likely to act as nuclei. Within the last two years, however, J. Aitken, one of the pioneers in this field, has come to the conclusion that ordinary dust is ineffective in this sense, whilst large ions and the particles given off by hot glass, porcelain and some metals (*e.g.*, magnesium, not aluminium, which, however, does not give smoke clouds like burning magnesium) are efficient, especially when in contact with flames. The X-rays from radium, on the other hand, did not appear to produce ions in the air. This fact seems to contradict the well-known experiments by C. T. R. Wilson on the production of mist and rain in suddenly expanded volumes of air when exposed to radiations. Wilson, however, experimented with air several times supersaturated. The influence of the violent pressure changes, rarefactions and condensations, accompanying the explosions, seems generally to be overlooked in these considerations. According to A. Wigand, who found that the passage of our earth through the tail of Halley's comet did not appear to have ionised the air noticeably, only hygroscopic dust, including soot, would condense the moisture. The Krakatoa eruption presented the world with dust clouds floating high up and with beautiful sunsets, but not with rain. Arago could not find that the occasional gun practice near Paris influenced the weather. At San Antonio, in California, tons of high explosives were blown up some years ago without disturbing the serene sky. The powder explosion of Tunis, 1887, cleared the sky and stopped the rain; the bombardment of Verdun in February, 1916, had no apparent effect on the rain at all, and the recent experiences are equally conflicting. Men like Angot, Deslandres, Lemoine, Sebert, seem to agree that the war years have not brought abnormal weather, and that the cannonades could only produce local rains if any. We shall have to wait till the end of the war for a critical examination of the evidence that we hope is being collected. For the present the problem is as controversial as most meteorological phenomena, the wind direction, the origin of big hailstones, of aurorae, &c.

Tap Cinder, Mill Cinder, Flue Cinder and Scale.—The Minister of Munitions has ordered that the war material to which the Regulation 30A applies shall on and after October 1, 1917, include: Tap cinder, mill cinder, flue cinder and scale produced during the manufacture or mechanical treatment of iron or steel. As from October 1, 1917, he permits all persons until further notice to buy, sell or deal in the war material referred to subject to the conditions he has defined and to the following maximum prices per ton f.o.t. or f.o.b., at purchaser's works, cinder and scale, produced during the manufacture or mechanical treatment of iron or steel, 1*l.* 10*s.* The above price includes any agents commission or merchants' or dealers' profit.

Brazilian Iron Ore.—We read in *The Iron Age*, New York, that the recent action of the Brazilian Government in cancelling the German-owned concessions and confiscating the German property generally throughout the Republic, will probably clear the situation in Brazil in regard to the iron ore deposits. The Brazilian ore, a specular hematite, runs from 68 per cent. to 70 per cent. of iron, it is low in phosphorus, and billions of tons can be mined above the surface. The deposits lie on a plateau 3,000 ft. to 5,000 ft. high, in a district which is healthful and in which there is abundant water power and favourable labour conditions. The Brazilian manganese deposits lie to the south of the iron district generally, and realisation of these deposits can be carried on extensively with the establishing of iron operations.

LITERATURE.

Steam Turbines: A Text-book for Engineering Students. By WILLIAM J. GOUDIE, B.Sc. Longmans, Green and Co. 1917. [Price 12s. 6d.]

ISSUED at a moderate price, Professor Goudie's treatise on the steam turbine is remarkably comprehensive, and though not many working drawings are reproduced, there are very many engravings and diagrams illustrating the most recent practice in turbine details. In the opening chapter the author points out the essential distinction between the reciprocating engine and the turbine. In the former the translation of the available energy of the steam into useful work is direct, whilst in the turbine the potential energy of the working fluid is first converted into kinetic energy, which is then, in its turn, converted into useful work on the shaft. Since losses necessarily occur at all such conversions of energy, the two-stage process should be less efficient than the single-stage one; as, in fact, clearly appears in the reverse operation, it being impossible to attain with a centrifugal compressor the efficiency realised on the compression stroke of a gas engine. That the steam turbine is nevertheless in practice able to compete with the reciprocator on more than equal terms arises in the main from the much higher ratio of expansion practicable and its freedom from losses by initial condensation and valve leakage. In his opening chapter, Professor Goudie describes and illustrates the characteristic features of all the principal patterns of steam turbine, whether of the impulse or reaction types, or whether high-pressure turbines, mixed-pressure turbines or exhaust steam turbines. More detailed data as to each of the main types are set forth in the succeeding three chapters, and are illustrated both by reproductions from photographs and by typical longitudinal sections of the principal makes. Reference letters have been added in profusion, so that the inexpert reader can identify instantly every item in the make-up of the machine which is referred to in the text. The numerous footnotes, giving references to publications in which the machines illustrated have been described in full, will no doubt be found of much service by readers desirous of further data on particular points.

The study of the theory of the subject is commenced in Chapter V with a discussion of the properties of steam. Professor Goudie begins at the beginning by defining the unit of heat, the relation between heat and work, the distinction between latent heat and sensible heat and other elementary concepts; he demands, therefore, no preliminary knowledge from the student, which will be of special advantage to those who have to conduct their studies without the assistance of a teacher.

Entropy diagrams are introduced in Chapter VI. We note here a misprint on page 94, where $\Sigma \frac{dh}{T} = 0$ should read $\Sigma \frac{dh}{T}$ is not less than 0. The author distinguishes between adiabatic and isentropic expansions, which, though quite defensible, is to our mind inexpedient and likely to lead to confusion; and, in fact, further on in the chapter the distinction seems to be abandoned. The whole point lies in the fact that, etymologically, adiabatic expansion means that no heat is supplied to the working fluid from without. If this definition be strictly adhered to various difficulties immediately arise. For example, in the Diesel engine the time of combustion is supposed to be prolonged, giving a more or less flat top to the diagram. Assuming the cylinder to be non-conducting, it would (if this original signification of the word adiabatic be retained) be accurate to consider the gas as expanding adiabatically under approximately constant pressure, since although heat is continually being added to the gas by its combustion, none of this heat is derived from without. This would certainly be confusing, and it is, we think, in every way better to abandon the originally restricted meaning of the term and take it in all cases as equivalent to isentropic. Both the temperature-entropy and the total heat-entropy diagram are discussed in considerable detail, and their practical applications illustrated by many fully worked-out examples. The flow of steam through a nozzle is next dealt with. The fact that there is a critical pressure ratio beyond which the usual formula for the discharge no longer applies is established in the usual way, but the author omits to give Osborne Reynolds' physical explanation of the anomaly, which is to be regretted, since most of us are ill-content with merely a mathematical demonstration of a physical fact, but like Maxwell, wish to see "how the thing goes." The further anomaly found in the discharge of saturated steam, which is frequently in excess of the calculated value, is discussed, we believe for the first time in a text-book, and explained, as was first done in our columns, by the supersaturation of the steam in the nozzle throat. It is probable, indeed, that the steam remains to some extent supersaturated during the whole of its passage through a turbine, once its superheat is lost, since Callendar and Nicholson found evidence of this condition even in the cylinder of a reciprocating engine. This condition of supersaturation greatly complicates any really exhaustive discussion of the steam turbine—the reciprocating engine is a still worse case. The effect will probably be generally ignored in practical work, any anomalies met with being provided for by suitable changes in coefficients.

As the author very truly observes, data as to nozzle efficiencies are far from satisfactory, but it is to be hoped that accurate figures will ultimately be provided by the Research Committee of the Institution of Mechanical Engineers, although it is unlikely that the actual experimental work can be commenced before the end of the war. It is not a little remarkable, though paralleled in the case of the reciprocating engine, that designers have attained the excellent results already recorded with turbines, with but an imperfect knowledge as to the real value of some of the fundamental coefficients involved. As Professor Goudie points out in his chapter on blading, we are still without any fully satisfactory theory as to the mutual reactions between the steam and the moving blades in a turbine. Blade heights designed in accordance with experimental results on blade friction are often found to lead to unsatisfactory results. Some secondary phenomena appear to be implicated which still require elucidation. There are, indeed, so many coefficients involved, that, over the limited range of conditions covered in turbine practice, an error in one can be compensated for by a suitable adjustment of another. Some designers assume, for example, low nozzle efficiencies and low losses in the moving blades, whilst others adopt an opposite view, but both find the results of calculation in fair accord with their experience.

Centrifugal stresses are fully dealt with in the section on rotors, although the author does not give the demonstration of the formulas quoted for the strength of discs. These formulas are unfortunately very complicated and difficult to apply, but Professor Goudie gives a series of plotted curves which greatly reduce the amount of arithmetic necessary and the risk of error. A clear explanation of the methods used for determining critical speeds is also included in this section.

In Chapter X a comprehensive survey is made of the various mechanical losses and their prevention, estimates being given of leakage losses past glands and dummies. For computing these in the case of labyrinth glands an alignment chart is employed. The accuracy thus attainable is amply sufficient for all practical purposes, in view of the unavoidable uncertainty as to the actual clearances and as to the true value of the coefficient of discharge. Perhaps the estimate made of the frictional losses at water glands would have been better based on Ryan and Gibson's experimental results on disc friction; these indicated that the losses increased somewhat less rapidly than the fifth power of the disc diameter, as in the formula deduced by Professor Goudie. The value of the head sustained also requires correction for the fact that the average value of the angular velocity of the vortex is considerably below that of the impeller. So far, however, this correction has not yet, we believe, been made in any text-book, though it has long since been found necessary by actual designers. With the usual type of impeller the head sustained is only 0.7 to 0.8 that given by the usual formula. An interesting calculation given in this chapter shows that the frictional loss at the turbine bearings is commonly less than 1 per cent. This is much below the values at one time accepted, which were mainly based on an erroneous application of Willan's law.

A particularly helpful chapter is that on the steam consumption of turbines, describing in detail what corrections are necessary to reduce actual test results to standard conditions. Included in this chapter is a detailed description of the heat accumulator used with exhaust-steam turbines and of the method of proportioning it in accordance with the character of an intermittent steam supply.

Two useful chapters on the preliminary design of a steam turbine follow, the reader's task being aided by the working out of a number of illustrative examples.

Special note should be made of the very full treatment of the theory of the Ljungström turbine, a type which, owing to the smallness of its leakage losses, seems likely to provide us with more accurate data as to the intrinsic efficiencies of reaction blading than have hitherto been available. In practice, of course, it has shown a phenomenal efficiency for turbines of small or moderate output.

Taken as a whole, Professor Goudie's treatise is a highly valuable addition to engineering literature. In the nature of things no text-book can be wholly up to date, since practice is continually changing, but in this case Professor Goudie has nearly achieved the impossible, his work including a description of many turbine details, the introduction of which is of very recent date.

Les Etablissements d'artillerie belges pendant la guerre. Par Commandant WILLY BRETON. Avec 61 illustrations hors texte. Preface des Émile Vandervelde, Ministre d'État. Paris: Berger-Levrault. 1917. [Price 6 francs.]

M. LE COMMANDANT WILLY BRETON is to be congratulated on having fulfilled a necessary and patriotic task with success and discretion. He has to make the world conscious that his country has not submitted tamely to Prussian masterdom, but that her spirit, alive and vigorous, is capable of well-directed exertion. Notwithstanding her overwhelming misfortunes, continuously, methodically, resolutely, according to her means, Belgium has struggled to maintain and equip from her own resources an army that is worthy of a free people determined on offering a serious resistance to an implacable foe. The author's patriotism is evident and avowed, but not misleading, and in this effort to place in a correct light the services his country has rendered to the Allies, he will meet with respectful sympathy. His aim, and it is one that is amply justified, is to exhibit the sustained courage of his countrymen, which the loss of home resources could not shake, and to insist upon the perseverance and tenacity that remained unbroken under the cruel blows of a ruthless enemy, who, baulked of conquest, took refuge in destruction. Much has happened and much has been forgotten since the public mind was shocked by the wreck of Louvain and humbled by the fall of Antwerp. Then the sacrifice required of Belgium and paid without stint was recognised to the full, but in the struggle of the last three years the sense of service has become so blunted by the recital of many tales of heroism and of suffering, that the first martyrs are liable to be lightly considered unless we are reminded of those bitter experiences.

It is no part of M. Breton's plan to plead the past services in the field or to insist on his country's deserts. He may recall with pride her loyalty to her Allies, and with regret the accumulated sufferings of her stricken people, but his object is to show how Belgium has laboured in spite of difficulties to resuscitate her army, to refit it for the field, to furnish it with suitable armament, and to reconstitute it as an organised unit among the massed nations, serving the cause of right and justice. How many people, he asks, are aware of the magnitude of the struggle upheld by Belgian authorities, in face of obstacles and impediments that would have defeated a less determined purpose, to maintain and restore the army, enfeebled by the battle and the victory on the Yser. He acknowledges the ready hospitality of France, the generous aid of Great Britain, the

welcome assistance of the United States, that have made such an endeavour possible and successful. He knows, too, the bitterness of exile on foreign soil, the feebleness that is the consequence of entire deprivation of home resources, the humiliation of enforced dependence upon the good-will of others, however willingly offered. The resuscitation of an army under such circumstances is a work of supreme difficulty, the arduous character of which has not been sufficiently realised. By a clear and ordered statement the author would make us understand what has been achieved, not as a challenge to our admiration, but in justice to his countrymen, who have never wavered in their task of winning back their country from the invader. The provision of munitions, the renewal of worn and injured armament, cannot claim the interest and the immediate recognition that is readily awarded to descriptions of gallantry in the field or to sucessful victory. He can only tell us of the number of guns that have been cast or relined, of the stacks of rifles that have been manufactured, and the quantity of explosives that have been sent to the front, and similar statistics. These are not the heroic side of war that commands public attention and applause, but the steady devotion exhibited in the factory is worthy of a chronicle. Week in, week out, by day and night, the monotonous work has gone on, unrelieved by the applause of the multitude and uncheered by the excitement of the campaign. M. Breton has watched the patient unwearied toil, knows its full value in enabling a small army to confront a numerous and well-equipped enemy, and is not a little hurt when he finds journalists, unappreciative, or indifferently informed, misrepresenting the facts. He is evidently smarting under a grievance when he complains that the new Belgian army is described as equipped and clothed, furnished with artillery and munitions, by the fostering aid of the Allies. The addition that the Belgian army to-day is a vigorous and valiant force, with which the enemy will have to reckon more than ever, does not entirely remove the sting, and certainly a main purpose in writing the book has been to show the extent to which Belgium has co-operated of her own means in the reconstitution of her army. Possibly he may resent the word "co-operation," for he writes, "C'est avant tout une œuvre essentiellement belge. Il faut bien le répéter, ne fût-ce que pour détruire une légende qui tend à s'implanter . . . la Belgique a pleinement conscience d'avoir lutté de toutes ses forces ardemment tendues vers la libération, pour reconstituer par tous les moyens en son pouvoir l'héroïque armée que la bataille de l'Yser avait anémiée à l'extrême."

In order to explain clearly what has been accomplished M. Breton describes the condition and organisation that prevailed in the Belgian arsenals at the outbreak of war. These establishments were on a modest footing, as became a nation whose position was guaranteed by a sacred treaty, binding on the great Powers. Arms and munitions were manufactured by the State at only two towns. A cannon foundry and a small-arm factory existed at Liége, and an arsenal at Antwerp, with which was connected L'Ecole de Pyrotechnie, the latter being more especially devoted to the production of projectiles and subsidiary apparatus. Such organistion was sufficient for defence, and in time of war would not have proved altogether inadequate, had not the plan of German attack and occupation deprived the country of a considerable part of its means of production. The German army precipitated itself on Liége in the first days of the war, not only rendering the cannon foundry and the rifle factory useless, but all the workshops and tools and industrial organisation in the neighbourhood fell into the hands of the enemy, paralysing the whole scheme of production. All that could be saved was naturally sent to Antwerp, but the partial disorganisation hampered the brave attempts to reconstitute the factories in that city. Still, while Antwerp could preserve her connections with the country freely, the situation was not utterly hopeless, and the existing, as well as the improvised, establishments struggled to make the output as great as possible. By the end of September, however, it became necessary to remove from that centre all that was most essential for providing the small army with the means of continuing its intrepid but unequal struggle. Weeks would have been needed to have effected the dismounting and ordered removal of the machinery, and practically hours had to suffice. How much was effected the victories in the plain of the Yser in October and November have told an admiring world, but as a matter of fact the artillery establishments ceased to exist as such, and the workpeople, arriving in France with empty but willing hands, found no machinery, or tools, or material at their disposal. They were black times, and despair no doubt filled many hearts, but M. Vandervelde, speaking with the authority of a Minister of State, assures us that from the first hours the Belgian colony struggled to supply itself with the necessary means of production to the fullest extent possible. At Calais repairing shops sprung up rapidly, and at Havre powder and projectiles were turned out on a fair scale. M. Breton tells the story of these struggling days, showing how difficulties were overcome and results achieved. By August, 1915, plans were so far matured that the necessary tools and materials were at command, and the workpeople were sufficiently trained and grouped to permit the Minister of War to issue instructions regulating the work of the several establishments under the sole control of the Belgian authorities, thus constituting a complete Belgian unit, though in a foreign land. All the service shops were grouped economically about the Havre centre under properly constituted authorities.

The first stage of reconstruction was complete, and henceforward success seemed likely to reward stern determination and prudent counsels. Labour and output increased encouragingly till December 15, when by a cruel fate occurred the fatal explosion in the Belgian powder factory. Not only was this building destroyed from top to bottom, burying in its ruins more than 100 workmen, but great havoc was occasioned in the neighbouring shops, some in full operation, others in course of erection. Work had to be suspended or curtailed till repairs could be effected. From this date more strenuous efforts had to be made to cope with accumulated disasters, but the will was equal to the need. Everything had to be begun anew. Workmen had to be found, and these in a large measure seem to have been "combed" out of the army. Scattered specialists from the factories of Hainaut, from Liége and Antwerp, formed a nucleus, who trained the unskilled refugees, and even the wounded soldiers. The want of machines was a great drawback, for England and France, with the best will in the world, were unable to supply these, being totally absorbed in their own industrial effort. America came to the rescue, and, as by magic, around Sainte-Adresse, Graville and the neighbourhood of Havre, with mushroomlike growth there sprung up fully-equipped buildings necessary for the forging of guns, the manufacture and filling of shells, the production of shrapnel, the repair of vehicles of all kinds, in a word for all the multifarious requirements of which the Belgian army was in need, and for which, in the future, the demand would be on a still larger scale. M. Breton shows how enthusiasm carried the enterprise to a successful issue, and how a greater arsenal, schemed on broader lines and better organised, rose to take the place of the hastily devised workshops that had to suffice the first urgent demands.

With conscious pride the author conducts the reader through the various factories, explains the purpose of each, showing how it has been organised and equipped, fondly lingering over the heaps of material that industrious hands have accumulated. We may envy him in his proud and happy task, for success is not to be measured by the quantity of output—that depends simply upon the number of hands employed—but by judicious disposition of all the means available, by economical arrangement and adaptation, by the character and number of the difficulties surmounted, and by the concurrence, the energy and the good-will that animates the staff of all degrees. Judged by such criteria, the Belgian Arms Manufactory has been eminently successful.

Finally, the author surveys the work of the Belgian contingent in England, though here his information does not appear to be so intimate and thorough as on the French territory, or it may be that he has to observe a greater discretion, imposed by circumstances. He has but little to say about the National Projectile Factory or the manufacture of explosives where the *personnel* is exclusively Belgian, but he congratulates his countrymen on being able to render an essential service to the British Government, notwithstanding the loss of working facilities at home. The village of Elizabethsville, called forth by the needs of the operatives, is sketched, and meets with general approval. It is described as a veritable piece of Belgium, its newly fashioned streets and avenues bearing the names borrowed from military history, or in memory of towns and cities martyrised by the invader. Roughly translating: "This village contains some 500 dwellings for married couples; each cottage arranged and adorned according to the taste of the occupier; spacious barracks for the unmarried; two immense refectories or dining halls, accommodating 2,000 diners; schools for the children of the workers, who receive instruction agreeable to the educational code enforced in Belgium; a Catholic church; a vast market for the use of the thrifty housewife, and, finally, a Belgian police to maintain order in a town larger than many of the rural agglomerations in our own provinces." M. Breton adds some further appreciative and complimentary remarks, for which we thank him, but which our modesty prevents us from quoting. It were better to conclude with the eloquent words of M. Vandervelde: "Mais, j'ose le dire, et l'on s'en convaincra mieux en lisant ce livre, quand le plateau de Sainte-Adresse sera de nouveau transformé en terrains à bâtir, quand les baraquements du Havre serviront d'abris à des réfugiès belges rentrés chez eux et que les machines de nos ateliers ne seront plus que du vieux fer, il restera quelque chose et quelque chose d'ineffaçable, de cette improvisation grandiose: le souvenir d'une des plus remarquables manifestations du génie industriel des techniciens et des ouvriers de notre pays."

Steel and its Heat Treatment. By Denison K. Bullens. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 17*s.* 6*d.* net.]

This work has been written by an American metallurgist and therefore deals with the subject from the American standpoint, but this does not detract from its usefulness. The subject is full of complex problems and variables, but the author is in a position to handle it from a practical point of view, and this has enabled him to treat it systematically and to pass over theories which are not of service in the workshop at the present time.

It cannot be said that there is anything very new in the methods or treatments described, especially in the earlier chapters of the book, but the author's clear descriptions, and advocacy for the necessity of close co-operation between the laboratory testing house and the workshop, should be read by those interested in the subject. He particularly draws attention to the advantages secured by systematic testing and standardisation of records in order that full information may be available for reference if it should become necessary to repeat the treatment or test. Such records are necessary to secure the co-operation of the laboratory with the expert and practical furnace hand, with the object of simplifying methods and improving the equipments for heat treatment in the majority of shops.

In the chapters viii and ix, dealing with heat generation and heat application respectively, the author opens by giving some good advice, namely, that in industrial heating "it is but hard common sense to state that there is no general solution applicable to the heating element or furnace," and, further, that "no single type of furnace, fuel, nor system of burning, can be applied as a 'cure all.'" The author suggests as a standard for the measurement of cost in industrial heating "the cost per unit of quantity of given quality"; he is not very clear, but if we understand him correctly, this does not alter the present method in this country of dealing with fuel costs; he may, however, desire to take out the costs in more detail.

The author advocates the use of fluid fuel (as distinguished from a solid fuel) on account of its

acknowledged ease of control, &c. As we have already mentioned, the book deals chiefly with American practice, and therefore it is essential to bear in mind the conditions pertaining in this country as compared with the States, and to make due allowances for transport and regularity of supply. It is necessary, as the author points out, to make the question of the fuel subservient to the quality of the finished product. Although these chapters may not draw attention to any striking innovation, they emphasise the importance of studying the problem from all sides, the fallacy of laying stress on the costs of equipments and the working expenses of the furnaces, &c., instead of on the production of a high-class finished product having due regard to output. The matter is one of engineering, simplicity of equipment with ease of operation, and above all, that the staff and employees are properly remunerated for operating a plant which cannot be regarded as "mechanical."

The chapter dealing with miscellaneous treatments is useful, but too brief, and the author's remarks on steel castings and forgings are apt. Mr. Bullen takes up fully the heat treatments required for carbon steels, alloy steels, tool steels, and, in an appendix, high-speed tool steels; and in the last chapter discusses the subject of pyrometers and temperature recorders, and the calibration and proper use of such instruments. It is hardly necessary to say that he is emphatic upon the advantages to be secured by their installation.

The book gives much information which is to the point, the illustrations and micro-photographs are excellent, while the index is a full one. Altogether it is a volume which cannot help but be useful to the student and those who are responsible for operations in the hardening and heat-treatment shop.

BOOKS RECEIVED.

The Preservation of Wood. By A. J. WALLIS TAYLER, Assoc.M.Inst.C.E. London: William Rider and Son, Limited. [Price 10*s.* 6*d.* net.]

Treatise on Milling and Milling Machines. Cincinnati, Ohio: The Cincinnati Milling Machine Company. [Price 6*s.* post free.]

Municipal Engineering Practice. By A. PRESCOTT FOLWELL. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 16*s.* 6*d.* net.]

Administration Report of the Commissioners of the Port of Rangoon. From April 1, 1916, to *March* 31, 1917. Rangoon: British Burma Press.

New Zealand: Railways Statement. By the HON. W. H. HERRIES, Minister of Railways, 1917. Including the Annual Report of General Manager of Railways. Wellington: Government Printer.

Little Stories from other Wars. By OLIVER BAINBRIDGE. With a Foreword by Lieut.-Colonel the LORD WILLOUGHBY DE BROKE. London: The Kharki Prisoners of War Fund, Imperial House, Kingsway, W.C.2. [Price 1*s.*]

The Railway and Commercial Gazetteer of England, Scotland and Wales. Compiled from Official Sources, Seventeenth Edition. London: John Gibson, 63, Coleman-street, E.C.2. [Price 15*s.* net, 17*s.* 6*d.* by post.]

Continuous-Current Motors and Control Apparatus: A Practical Book for All Classes of Technical Reader. By W. PERREN MAYCOCK, M.I.E.E. London and New York: Whittaker and Co. [Price 6*s.* net.]

Power Winding Diagrams: A Handbook of Connection Diagrams of Control and Protective Systems for Industrial Plants. By A. T. DOVER. London and New York: Whittaker and Co. [Price 6*s.* net.]

The Works Manager To-day: An Address Prepared for a Series of Private Gatherings of Works Managers. By SIDNEY WEBB. London, New York and Calcutta: Longmans, Green and Co. [Price 3*s.* 6*d.* net.]

THE COAL CONSERVATION COMMITTEE.

THE Ministry of Reconstruction some time ago appointed a committee named the Coal Conservation Committee to consider the economy that might result from the conservation of coal in the production of motive power and other forms of energy for industrial purposes in this country, the expansion of industry which would result in the way of new manufactures from the proper use of coal, and the steps necessary to attain these objects. The report of this committee is in the printer's hands, and will shortly be published. In the meantime, we have received an early proof of the recommendations, which are as follow:—

RECOMMENDATIONS.

1. It is essential that the present inefficient system of over 600 districts should be superseded by a comprehensive system in which Great Britain is divided into some sixteen districts, in each of which there should be one authority dealing with all the generation and *main* distribution.

2. Centres, or sites, suitable for electric generating purposes should at once be chosen on important waterways as the future main centres of supply for each of the districts into which the country is to be divided.

3. The sites so chosen should be as large as possible, having in view the land available in suitable localities, and should have ample water and transport facilities. Land is required not only for the power stations themselves—which, for the sake of security and safety would have to be suitably sub-divided, that is, they would not be contained all in one building—but for the processes involved in the extraction of by-products from the coal before it is used for the production of power, where such extraction is found to be justified. It is also required for the development of electro-chemical processes, which may be most conveniently carried on in close proximity to the power plant. This condition entails the sites being chosen outside, not inside, towns. (The health of the great industrial centres and the congestion of the railway lines in their neighbourhood would be radically improved by arranging that the conversion of coal into motive power was carried out away from the densely populated centres).

4. Plans should be prepared for the construction immediately after the war on these sites, of the first instalment of large super-power plants capable, first, of supplying, through a comprehensive electric power distribution system, which must also be arranged for, the existing demands of the community: and, secondly, of supplying electrical energy at the lowest possible price for new processes and manufactures.

5. Such plants would be designed so that, as methods are perfected for extracting by-products from the fuel, before using it for the purpose of the production of electric power, the by-product plant can be combined with the power plant. Each site should be laid out with this in view, and with a view to the unrestricted extensions of the plant, as required.

6. Power available from surplus gas or waste heat should be turned into electrical energy on the spot in local plants, which would feed into the main distribution system. As regards waste coal—*i.e.*, coal which it does not at present pay to bring to the surface—this could, where transport was the ruling consideration, also be used on the spot.

7. Once these plants are in existence it would be possible for existing authorities, without any risk of being left in the lurch, to stop extensions of their own uneconomical stations, situated as they mostly are on cramped and unsuitable sites, and to arrange to take their power from the main system.

8. With a view to carrying out the policy advocated a Board of Electricity Commissioners should be appointed with full powers to deal with the electricity supply situation throughout the country. They should have power—*inter alia*—

(*a*) To stop the extension or multiplication of uneconomical stations for public supply.

(*b*) To arrange for the handing over, on equitable terms, of the generation, transmission and main distribution system in each of the areas into which the country is to be divided, to a new electricity body appointed for that area.

(*c*) To standarise for each area the frequency and voltage of the main transmission and distribution system.

(*d*) To settle for each area whether such body should consist of a Parliamentary company working under adequate control, as regards limitation of dividends, &c., or one of the other alternatives given in Appendix C.

9. Alternative types of the new electric power organisations are described in Appendix C. In reference to these alternative types the Sub-Committee are impressed with the special need for initiative and resource in the management of the business of power supply, and they are of the opinion that the freedom of range and keenness which are distinctive of private enterprise, will be found to be in a high degree conducive to the fullest measure of success. The Sub-Committee consider that if the nation is to get immediately an efficient power supply, and is to take advantage of the temporary lull in manufacturing output immediately after the war, State assistance in some form may be necessary.

ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.

A SECOND conference of delegates from branches of the Association of Engineering and Shipbuilding Draughtsmen was held in the Grosvenor Hotel, Deansgate, Manchester, on December 15 and 16. The conference was attended by the president, Mr. W. Herd, and the retiring general secretary, Mr. L. Blair, *ex officio*: and, in addition, 33 delegates, representing a total of 22 branches of the association.

The proceedings opened at 8.45 p.m. on the 15th inst., when, after the roll-call, Mr. E. H. Walker (president, London branch) was unanimously elected to occupy the chair for the conference. The *résumé* of the proceedings of the conference held at Leeds on August 18 and 19, 1917, having been taken as read, the immediate business before the conference was the election of a general secretary in succession to Mr. Blair. The convener of the sub-committee of the Leeds Conference, in a short statement, informed the delegates that, as a result of advertisements in various journals, a total of 95 applications had been received. From the total number of applications received a short list of five had been selected by the sub-committee for submission to the conference, and the five applicants were in attendance for the purposes of interview if desired.

The method of procedure having been determined, the candidates were each accorded an interview before the delegates assembled; after which the selection was made by ballot, resulting in the election of Mr. Peter Doig, of Glasgow, as general secretary of the association. The conference was then adjourned until the following morning. At the outset a very hearty vote of thanks was accorded to Mr. Blair for his services to the association from 1913 until the present date. It was further agreed that the arrangements for the transfer of the headquarters of the association from Glasgow to London should be left in the hands of the present executive committee.

The main business of the day was the consideration of the proposed rules governing the association. A draft list submitted to the conference by the rules sub-committee of the Leeds Conference was discussed in detail and finally, at a late hour, were agreed upon. The question of the registration of the association as a trade union having arisen in connection with the rules the delegates unanimously agreed to recommend that steps should be taken to effect such registration. Accordingly it was arranged that the rules, having been passed in a form suitable for registration under the Trades Union Acts, shall be printed forthwith and issued to the members, accompanied by a suitable circular, which shall be drawn up by the executive committee, and the opinion of the members ascertained by means of a vote on the card system: and in the event of it being found, on reports received from branch secretaries, that a majority of votes recorded are in favour of registration, the executive committee shall be authorised to proceed with the registration.

The financial arrangements between headquarters and branches was next considered, and after discussion it was decided to instruct the executive committee to draw up a scheme to suit the general circumstances, which scheme shall be circulated to the branches. The question of the relations between branches and sub-branches was raised, and after considerable discussion it was agreed, on the suggestion of the chairman, to leave the question to be investigated by a special sub-committee of the executive committee.

On the subject of technical papers published by branches, it was decided to ask each branch to forward copies of papers and details of technical educational schemes to the publication committee to investigate in order to establish some standard scheme for general application.

The election of officers was next proceeded with, and Mr. W. Herd was unanimously elected president of the association for the year 1917–18, and Mr. E. H. Walker, vice-president.

It was announced on behalf of the executive committee by Mr. Herd that the members' subscription for the period March 1, 1918, to August 31, 1918, should be 5*s.*, which was agreed to. The conference closed with the usual votes of thanks. The next conference is to be held in May, 1918, at Newcastle-on-Tyne.

THE EXERTIONS OF THE GERMAN SHIPBUILDING INDUSTRY.—The German shipbuilding industry is anticipating great and unprecedented activity after the conclusion of the war. Although the vast aid grant to the German shipping industry no doubt to a great extent will find its way to the shipyards, many of them have found it expedient to increase their capital, their plant, and in many cases their area. The smaller yards have in many cases displayed much energy, whilst some of the largest yards, amongst them the Vulkan, in Stettin, and Bremen, have hitherto held back as regards the issue of new capital. The following table contains some particulars of increase of capital of shipyards:—

	From Marks.	To Marks.
August, 1916—		
Blohm and Voss, Hamburg	12,000,000	20,000,000
June, 1916, to November, 1917—		
Howaldtswerke, Kiel	4,100,000	10,000,000
March, 1917—		
Reiherstieg Yard, Hamburg	5,000,000	6,000,000
September, 1916—		
Atlaswerke, Bremen...	6,000,000	7,500,000
April, 1917—		
Frerichs and Co., Bremen	3,000,000	4,500,000
July, 1916—		
Neptun Yard, Rostock	2,200,000	3,000,000
October, 1917—		
Nüske and Co., Stettin	2,000,000	3,000,000
November, 1916—		
Stettin Oderwerke ...	1,736,000	2,600,000
May, 1916—		
Koch Shipyard, Lübeck	600,000	3,600,000
July, 1916—		
The Joh. C. Tecklenborg Yard ...	5,000,000	6,000,000
November, 1917—		
Jansen and Schmilinske, Hamburg ...	300,000	3,000,000

Not only have, as will be seen, a number of old yards increased their capital with a view to increasing their capacity, but some new shipbuilding concerns have been formed or planned, including the Hamburg Yard, Hamburg, started by the Allgemeine Elektricitäts Gesellschaft and the Hamburg-American Steamer Company, in conjunction with the yard started by the Sekuritas concern in Hamburg; two yards in Lübeck, yet to be built, the one by the firm of Koch Brothers at the mouth of the Trave, and the other in connection with the Düsseldorf firm of Goldhardt. Also, in Stettin and Emden, new shipyards have been projected, and in Tönning, the Hansa Company is about starting a shipyard on the site of the old Eider yard.

BRITISH MERCHANT SHIPS TORPEDOED AND GERMAN SUBMARINES SUNK.

The Secretary of the Admiralty makes the following announcement:—

In view of the statement made by the First Lord in the House of Commons on Thursday, December 13, that the general curves of merchant tonnage sunk by enemy action, and of German submarines sunk are satisfactory, it has been thought that the public would be interested to see these curves, and they are reproduced herewith.

With regard to the first diagram (Fig. 1) the height of the enemy submarine attack upon merchantmen

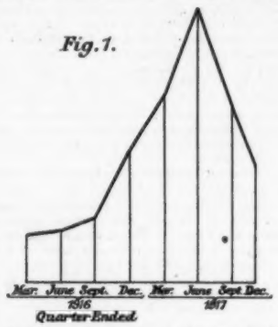


Fig. 1. Losses by Enemy Action of Merchant Tonnage—British, Allied, Neutral.

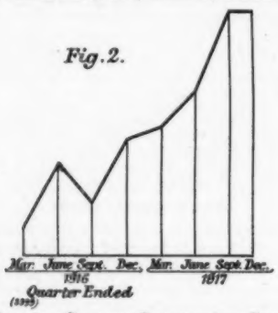


Fig. 2. German Submarines Sunk.

These diagrams are:—

Statistically accurate, based on facts up to December 17 and include no estimated or uncertain figures.

Diagrammatically accurate and strictly to scale, but obviously not to a uniform scale.

was in April, 1917, and that accounts for the quarter ending June showing the "peak," since when the curve has steadily fallen, and in the last quarter of this year has reached the same figure as in the last quarter of 1916, which was before the unrestricted submarine attack began.

The second diagram (Fig. 2) shows that since the quarter ending September, 1916, there has been a steady rise in the number of submarines sunk, and although for the last quarter of 1917 the number sunk has not further risen, it must be remembered that there are still the results of half a month to add, and we have already equalled the results of the quarter ending September, 1917.

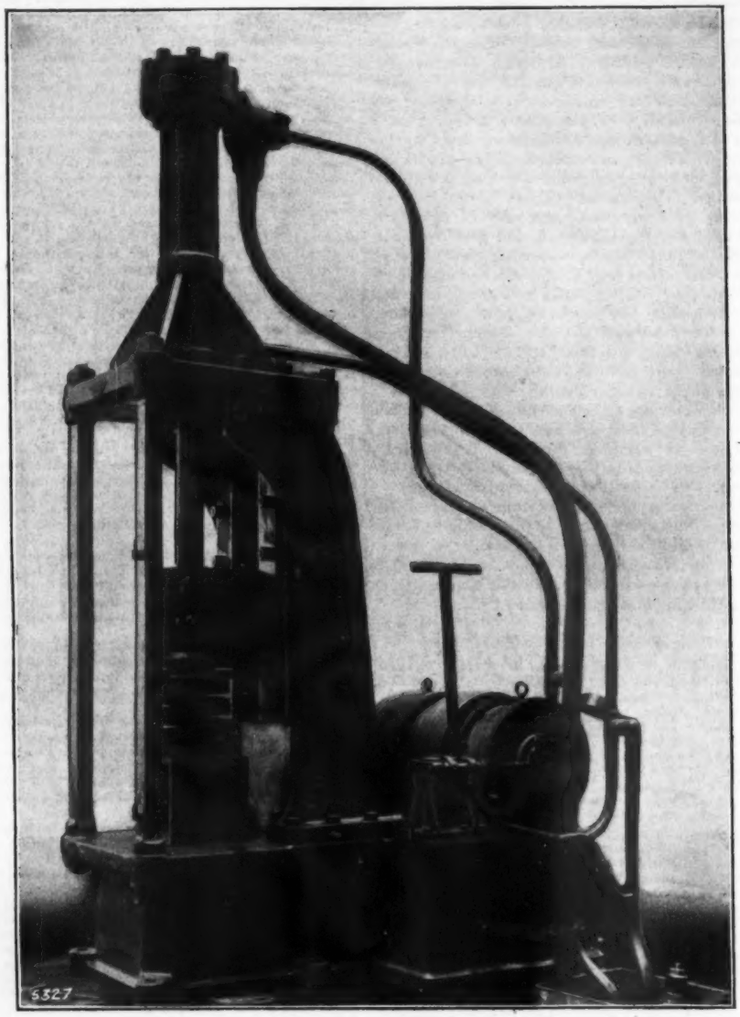
Attention is particularly drawn to the notes at the foot of the diagram, which explain that they are statistically accurate and drawn to scale, but that obviously the scale is not the same in both, one being for *tonnage* of merchant vessels, and the other the *number* of submarines.

Control of Steel Supplies.—The Minister of Munitions has extended the provisions of the Order made by him as to the control of certain classes of steel dated November 20, 1916, to steel in shell discard quality and steel made by electrical process.

Annual Inspection of Commercial Motors.—The twelfth annual inspection of commercial motors and examinations of drivers, organised by the Commercial Motor Users' Association with the object of encouraging drivers, to take a personal interest in the driving and condition of their vehicles, and to run them without accident, will take place in London during May, 1918: but the usual assembly, or parade, of vehicles will not be held, owing to the difficulty of sparing vehicles from service during the present period of stress. Full particulars of prizes and entry forms may be obtained from Mr. Frederick G. Bristow, F.C.I.S., Secretary, The Commercial Motor Users' Association (Inc.), 83, Pall Mall, London, S.W. 11.

HYDRAULIC SPRING SCRAGGING MACHINE.

CONSTRUCTED BY MESSRS. SAMUEL DENISON AND SON, LIMITED, LEEDS.



We illustrate above an interesting machine which is being constructed by Messrs. Samuel Denison and Son, Limited, of Leeds, for scragging springs of all classes without the use of steam, the necessary action being obtained by the employment of oil supplied under high pressure. As will be seen from the engraving the machine consists of a cylinder provided with a piston ram and mounted on a suitable standard fixed on a box bed, to which the base of the cylinder is also connected by steel tie rods. The tup at the lower end of the piston rod is provided with a slipper working in guides carried by the main standard.

The oil is forced into the cylinder by means of a high-frequency rotary pump invented by Dr. Hele-Shaw, Messrs. S. Denison and Son having the sole licence for the use of this pump for this purpose. The success of the machine for its special work may be said to depend entirely upon the special features of the pump named, which permit the scragging operation to be controlled by rocking a hand lever to and fro in exactly the same manner as is customary with a steam scragg.

The pump and cylinder are fed with oil from a small tank sunk below the floor level. The pump is rotated at about 1,000 revolutions per minute, and may be driven either by electric motor or by belt from shafting. In the case of the particular machine illustrated it is driven by a 15-h.p. motor giving a maximum pressure upon the spring of 15 tons. The speed of the tup is arranged to give 20 complete strokes per minute. the length of stroke being 18 in. The up-stroke is made at three times the speed of the down-stroke, When scragging a short spring a speed of 75 strokes per minute can easily be attained.

The pump is capable of exerting a pressure of 2,000 lb. per square inch. A heavy flywheel is interposed between the motor and the pump to store up energy during the periods when the spring is returning to its normal position—namely, during the up-stroke of the tup. This arrangement reduces the consumption of current to a minimum, making the machine very economical in working. It may be pointed out that the Hele-Shaw high-frequency pump requires no control valves beyond the usual foot valves in the tank, and has no packing to wear or get out of order. In this case, using oil, it is of course self-lubricating. A large relief valve inserted in the pipe system so as to be entirely immersed in the oil tank enables the full pressure to be held upon the spring at will without doing injury to the pump.

Messrs. Samuel Denison and Son have already made several machines of the type described, varying in size from 2 tons up to 15 tons, and we understand that they have given complete satisfaction. There appears to be no reason why the type should not be adopted for very much larger sizes and we expect to see it so used.

Meteorological Office, London University Lectures.—A course of nine lectures on "The Practical Applications of the Study of Weather," will be held at the Meteorological Office by Sir Napier Shaw, as University Reader in Meteorology, on Fridays, at 3 p.m., beginning on January 25, 1918. Students wishing to attend should communicate with the reader at the Meteorological Office, Exhibition Road, London, S.W. The course is intended for advanced students of the university, and others interested in the subject.

DEVELOPMENTS IN ELECTRIC LOCOMOTIVES IN ITALY.

Fig. 11.

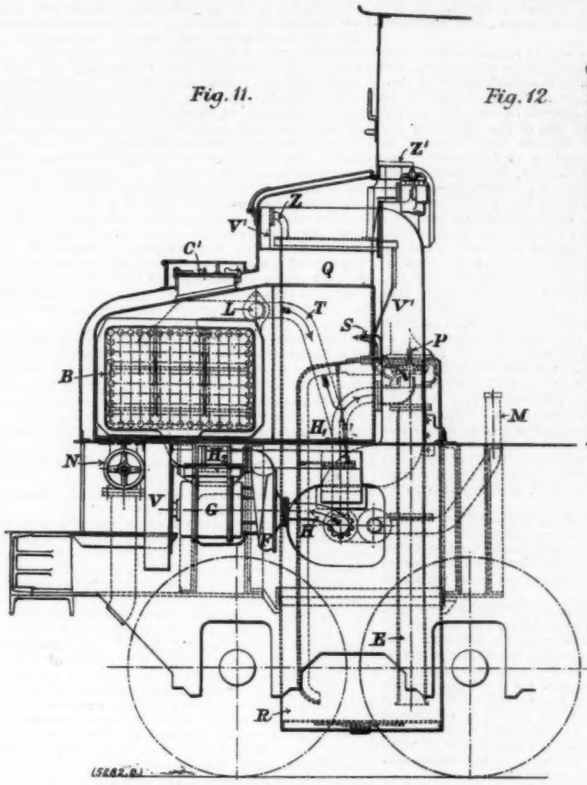


Fig. 12.

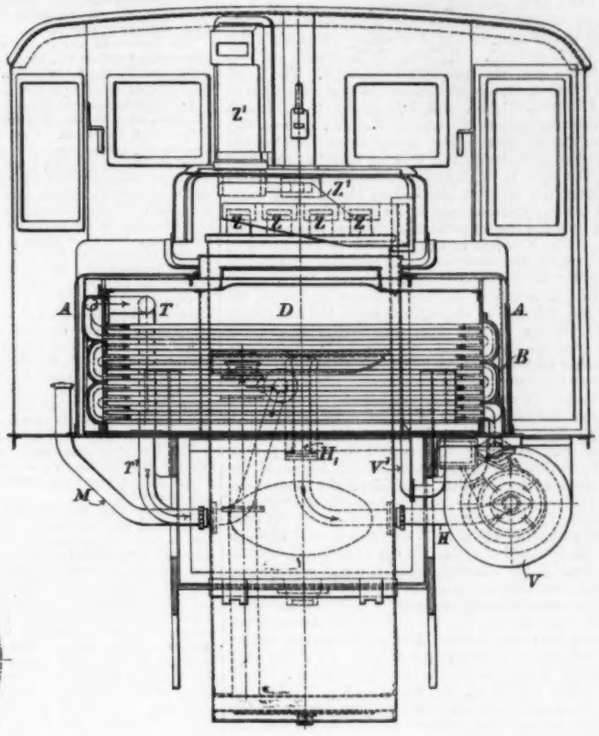
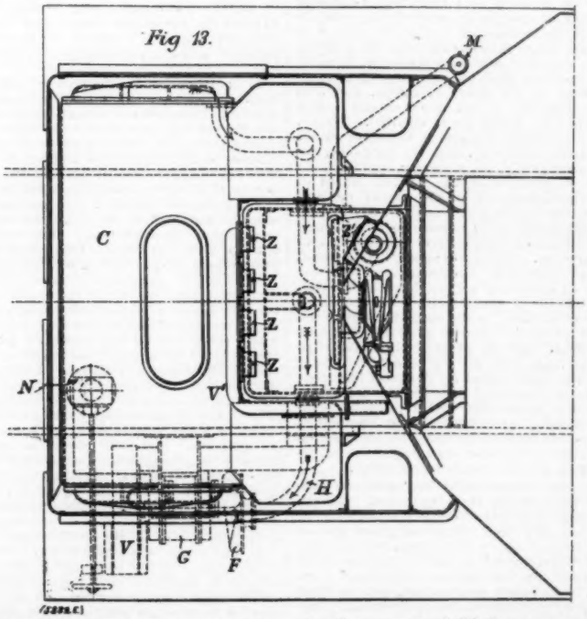


Fig 13.



DEVELOPMENTS IN ELECTRIC LOCOMOTIVES IN ITALY.

(*Concluded from page* 624.)

A FURTHER improvement carried out in the Italian electric locomotives concerns the increase in the capacity and efficiency of the liquid rheostats carried by the engines. It may be remarked that the electric locomotives in question were first designed for service on the Pontedecimo–Busalla line, on which, in ordinary circumstances, there are practically no stoppages, and no re-starting when the engine has commenced running from the terminus, and the original rheostat, although it had a capacity of 500 litres only (110 gallons) of soda solution and was not fitted with a cooling device, was found sufficient for the work. When, however, electric traction was extended to longer runs, such, for example, as that from Genoa and Savona, and when stoppages at intermediate stations and consequent re-starting became more frequent, conditions which were combined with an increase in the train loads, the insufficiency of the rheostat became apparent, and this was further aggravated by an increase in the train speed which, following upon an increase in the frequency of the current, was raised from 45 km. to 50 km. (28 miles to 31 miles) per hour.

In the engines numbered 41 to 85 the difficulty was met, in part only, by increasing the volume of the soda solution to about 700 litres (155 gallons) and by providing a centrifugal circulation device for delivering to the casing containing the electrodes a continuous supply of the cooler portion of the solution. The device was completed by a ventilation pipe which started from the ventilation duct of the motors and ended on the rheostat tank. These means did not give in actual practice the results hoped for, and in the locomotives 86 to 130 the capacity of the rheostat was increased, and it was fitted with serpentine cooling pipes. The action of the rheostat was notably improved thereby; the arrangement at best, was however, but a makeshift, and among the difficulties which remained to be overcome was that of rapidly re-establishing the normal working conditions of the rheostat when the solution it contained had reached a temperature such as not to allow of re-starting the engine. The expedient of renewing the whole of the soda solution took up considerable time and led to unnecessary expense, whilst renewing it in part only produced unsatisfactory results. It was necessary, therefore, to devise an adequate arrangement, quite apart from increasing still further, within the limits available, the capacity of the rheostat, it being evident that the cooling down of a larger amount of solution on the process hitherto followed would have increased both the time lost and the cost.

The above considerations led the Italian State Railways to add to the engine, besides the soda solution in the rheostat, a body of water to act as a cooling medium and easy to renew at any terminal station, or at any intermediate station in the case of long runs. The new device is illustrated in Figs. 11 to 13, the references to which are the following:—

A, tube plates; B, B, headers; C water tank; C', opening for filling the water tank; D, nest of cooling tubes; E, suction pipe for the circulation of the soda solution; F, centrifugal pump; G, electric motor; H, suction pipe of the centrifugal pump; H_1, suction opening; H_2, delivery pipe of the centrifugal pump and ingress of the soda solution to the cooling nest of tubes; L, outlet of header; M, filling pipe of the rheostat tank R; N, discharge valve of the water tank C; P, centrifugal circulation apparatus; Q, casing containing the rheostat electrodes; R, rheostat tank; S, solution inlet in the electrode container; T and T_1, solution outflow pipes from the cooler; V, rheostat fan; V_1, ventilation pipe; Z, air openings to the electrode container; Z_1, vapour outlet from the electrode container.

The rheostat with its tank R, the circulation apparatus P and the accessories connected therewith are similar to the corresponding parts fitted to the locomotives 41 to 85 above referred to, except that the capacity of the rheostat tank R is greater by about

360 litres (80 gallons), the tank having been deepened whilst the rheostat has been raised by about 70 cm. (27 in.) the total quantity of soda solution is about 1,260 litres (280 gallons), including that contained in the nest of tubes D and in the headers B. The cooling water tank C has a capacity of about 1,300 litres (288 gallons). Its end walls consist of the tube plates and the cast-iron headers B. The tubes number 150, their dimensions are 24 mm. and 28 mm. by 1,875 mm. ($\frac{15}{16}$ in. and $1\frac{1}{16}$ in. by 6 ft. 2 in.), and their cooling surface about 25 sq. m. (269 sq. ft.). The centrifugal pump F is keyed at one end of the electric motor shaft, the fan V being keyed at the other end. The pipe H of the pump F opens in the casing containing the rheostat electrodes; the opening is enlarged at H_1, so that in case of an excessive consumption of solution the pump always remain primed. The action of the pump is further insured by the rising of the solution in the rheostat casing which is produced in starting by the compressed air supplied to the rheostat tank R. A switch is provided to put in circuit the pump and fan set at the same time as the fan of the traction motors, or the latter can be started running alone, and can also be cut out separately by means of another switch. The two sets can thus be isolated one from the other on an emergency. The header B is connected to the delivery pipe of the pump F and the upper header is fitted with the outlet L, to which the pipe T is connected. This runs through one of the rear ends of the tank C, and is continued by the pipe T_1, which enters the tank R and opens in the upper part of the suction pipe E of the centrifugal circulation apparatus P directly beneath the rotor of the latter. A ring-shaped space is left free between the end portion of the pipe T_1 and the pipe E through which the circulation apparatus draws from the bottom of the tank R the rheostat solution which is delivered into the electrode container at S, together with that which proceeds through the pipe T_1. The ventilation pipe V_1 connects the fan V at Z above the cover of the electrodes; on the other side is the vapour outlet Z_1, which has a clear section of over six times that provided in former rheostats, *i.e.*, 125 sq. cm. (19.38 sq. in.) instead of 20 sq. cm. 3.1 sq. in.).

Before switching-in the rheostat, the motor of the pump-fan set and that of the traction motor fan, are switched-in simultaneously. Starting is then proceeded with by inserting in the circuit the stators of the traction motors and delivering compressed air into the rheostat. The solution rises and the circuit of the circulation apparatus P closing automatically starts the apparatus running. The pump F draws from the electrode container the solution which becomes heated during starting, and delivers it below the rotor of the circulation apparatus through the nest of tubes D, where it makes five turns transmitting heat to the water; the circulation apparatus P delivers into the electrode container the cooled solution together with that which is drawn from the bottom of the tank R. Owing to the capacity of the circulation apparatus P, an active substitution is maintained round the electrodes of cooled solution for that which has become heated. Since, in order to obtain the result aimed at, it is necessary to replace round the electrodes in a given time the largest possible quantity of solution, it was found advisable to maintain the circulation apparatus P, besides the pump F, rather than have resort to one circulation pump alone equal in power to the two, owing to the notably greater head which would have been necessary to overcome the friction in the nest of tubes D, and in the pipes T and T_1, which latter could not easily be given a greater internal diameter than 70 mm. ($2\frac{3}{4}$ in.). On the other hand, with one pump alone the power consumption would have been greater than that required for the pump F and the circulation apparatus P; the single pump, moreover, would have had to be given dimensions incompatible with the space available for its location. The duty of the pump F under a total head of about 5 m. (16 ft.) is about 650 litres (144 gallons) per minute. There being 1,260 litres of soda solution, this is thus made to circulate completely more than once through the cooling system for each starting operation.

THE QUESTION OF SCIENTIFIC MANAGEMENT.*

By Mr. James Richardson, B.Sc.

To meet the industrial requirements of the present and of the future, the outstanding necessity is greater efficiency of production to effect an increase both in volume and quality of output by improved organisation and the elimination of waste effort and of friction rather than by an extension of the working hours. A great amount of literature dealing with the subject is available, but definite solutions are not always presented. In the following brief paper the author has attempted to state the case in certain of its phases and primarily to point to the needs of improved works management. The conditions in the industrial world are changing rapidly, and the first consideration must be to state, shortly the trend of such change and to equate thereto proposals for improvement. In order to keep a treatise of this nature within desirable limits of length, first principles only can be discussed.

The lessons of war time, in regard to the necessity for maximum production, have been largely assimilated, and have proved the advantages of standardisation of product and of repetition work, which lie principally in the possible reduction of effort required to turn out a given product, and in the decrease also of the designing and supervision charges. Jigs, fixtures and working to limits, are more generally applied to minimise fitting work and to cut out idle machine time. Standardisation, however, should never be carried to that degree which would impose an undue limit on ingenuity and reasonable progress: but the programme of reconstruction necessary immediately on the cessation of hostilities, coupled with the lessons learnt, suggest a greater degree of standardisation than can be regarded as normal in unexceptional circumstances, or, as generally desirable for due and reasonable progress. On analysis it will be found that in every works there is a very considerable amount of work which, although not generally considered as such, is virtually repetition work, in that it is composed of elementary operations recurring continuously, to which can be applied with considerable profit the same study as is given to the usual type of repetition work. The extension of automatic and semi-automatic machine work, the displacing of hand operations by machinery, is a movement in the path of development which has been quickened.

The foregoing has reference merely to products; as regards standardisation of tests, methods, tools, equipment, &c., a great amount of work still remains to be commenced.

Together with the benefits of standardisation in both directions, the maximum industrial efficiency demands the fullest concentration of each works to the exact measure of possible economic specialisation on that design and quality of product for which it is most suited in respect of plant and personnel.

With increasing specialisation precautions should, however, be taken to ensure that the requisite numbers of good all-round engineers will still be trained. The engineering industry of this country has gained a proud position mainly as a result of the all-round ability of the average British engineer, and we must not neglect that individual ability which has served us so well in the past. The trend towards the provision of greater opportunities for the recognition and the advancement of those who show capacity for a broader line of work than that consequent upon a degree of specialisation, should produce able designers and staff.

Better conditions of work and high wages conduce to greater efficiency of production, and efforts must be made to reconcile the somewhat conflicting claims of efficient production and of fulness of life for the workers.

With regard to wages, it is not always borne in mind that national income is in great measure dependent upon the aggregate value of the goods produced, and also that the individual worker by his efforts should largely determine the wage to which he is entitled. Wages, however, have permanently become a factor of much more importance than hitherto, and for guidance, we may turn not unnaturally to a nearer approach to these conditions as prevails in the United States of America. The distribution of wages should be proportionate to the importance and value of the function performed, and these functions require to be reviewed and revised in the light of their relative importance and value to the community. The law of supply and demand, the exigencies of abnormal circumstances, and the relative strength of disputing parties, have in the past caused some distortion of perspective, with detriment to certain classes of workers, to the industry, and to the community. The gravest difficulty probably concerns supply and demand, and to prevent this law from influencing the earnings of a worker to a figure lower or higher than can be apportioned for the exact function, we must look to co-operation between the industrial and the educational authorities and to a fuller conception of the meaning of industrial and economical influences. Corrective factors—namely, the introduction of suitable machinery, and the encouragement of invention—tend continuously towards re-valuation.

So far as the conditions briefly reviewed are concerned, substantial progress is being made. On the other hand, investigations carried out in connection with the steel, iron, coal and other industries, prove that in this country, in normal times, the output per man per annum in these industries fell below the output of the Americans and Germans, who are generally much more fully instructed, often better conditioned, and far more generously equipped with the necessary tools and plant than are British workers. Moreover, from various quarters, there are available proofs which show that a large proportion of the average skilled workers in this country at the present time are turning out less work per unit of time than they did before the war. In other words, the average intensity of work is lower. This may be due, in a measure, to several factors, amongst which might be stated:—

1. Industrial unrest arising from numerous and well-known causes, partly peculiar to the conditions of war.

2. Notably less unemployment at the present time than ever before, and the employment of a higher percentage of the workers on a grade of work more important than that to which their ability entitles them.

3. A certain degree of weariness resulting from the long hours of continuous work that were regarded as necessary at the beginning of the war, and, in some quarters, unfortunately, still considered advantageous in affecting increase of production, in spite of convincing proofs to the contrary.

The first and second conditions are more or less temporary, and need not affect the general argument. As regards the third, it is substantially demonstrated that for a given type of work and an average worker, there is a period of duration of effective work, to exceed which means generally such a decrease in rate of output as reduces the overall production. Again, owing to its large effect in increasing the earnings of the workers, a certain amount of overtime, including Sunday work, is regarded most favourably by them, and little effort to avoid overtime can be looked for from the workers. These two considerations are, of course, entirely exclusive of measures required to carry exceptional peak loads often in the face of shortage of labour, or of sudden exigencies, to meet both of which overtime is inevitable. On the other hand, the greater the degree of organisation the less the overtime required. Intensity of work, although variable, is generally decreasing. It might be considered that undue prominence has been given to this factor: but a certain amount of false optimism is to be found in statements dealing with this subject which it is necessary to temper in order squarely to face the facts.

There are, of course, other causes which, after the war will tend to decrease the total production of the nation (exclusive of agriculture). Of these but a few need be enumerated, and without comment;—

1. Emigration.
2. Increased agricultural activity.
3. The partial return to non-productive occupations of women workers.
4. The reaction that usually follows a period of tension.

The first three have reference merely to total production and the fourth to intensity.

If, however, by means of exact study, it were possible to utilise the special knowledge of the highly skilled craftsmen, and to apply it by means of systematised training to the most suitable workers of the same trade, advantages in the direction of augmented output would undoubtedly result. Hand and eye training in the school, intensified and direct apprentice training in the works, and more generous opportunities for attending technical courses of instruction, will tend in time towards future increased production. The full effects of the present decided move in the direction of better education will not be felt for some time, and the intervening period is that with which we are primarily concerned.

It might be urged that our organisation cannot be very deficient since, through character, enterprise, and individual national ability, our industries had achieved the high position which was undoubtedly theirs when it could last be reviewed, and that since, even in our state of relative unpreparedness, we have been able rapidly to meet the necessities of this war. This is substantially true, although the needs of the future, to avert bankruptcy,* will call for management nothing short of the best.

It is primarily the purpose of this paper to equate scientific management to the conditions aforementioned. Scientific management means briefly the determination and the putting into practice of exact laws in regard to management, and it is a pleasing sign of awakening interest that reference is now made so frequently to scientific management in most of the Government, and in almost all other publications dealing with the subject of the future of industry. No attempt will be made to describe the system in detail, as that has been done most eloquently elsewhere.† The details can be worked out to suit individual requirements, and the first principles need only be enumerated now.

1. Scientific management is a system based on the conception that the whole routine of the works, down to the last detail of every operation, is organised by the management, so that confusion, over-lapping, delay and waste (both human and material) are avoided, and the course of the work is planned to run as smoothly, rapidly, and as efficiently as possible. This system applies not only to works management, but also to costing and all the other accessories. There is yet little recognition in this country of the necessity that costing should be undertaken by those who have a real knowledge of the work in question. Generally there is more improvement possible in arrangement for costing than in any other department of works. Costing can and should be the greatest asset to the management; it should be the pulse of the whole organisation, instead of being merely an approximately accurate record of performance in the past—sometimes in the distant past.

2. The design and installation, or adaptation, as may be necessary, of the best machinery, tools, fixtures and gauges to undertake the work in view are, of course, preliminary steps, and should be carried out in as complete a manner as foresight and the probable future conditions may warrant, balancing exactly the relative values of the plant cost as against the saving in wages. (The saving of the wages of one man means interest, depreciation allowance, &c., on a capital of over 1,500*l.*)

3. The workers are most carefully selected for the work in view, and are trained to achieve the best results in their chosen spheres. Selection and training are thoroughly understood, and are excellently applied in Britain where sports are concerned. There is little of the haphazard about the placing of men in the football or in the cricket field, or the choice and position of members of an eight in rowing. Training, further, is carried out

* Paper read before the Institution of Engineers and Shipbuilders in Scotland on December 18, 1917.

* Dr. Addison, on November 7, 1917, said; "Unless we can produce more we shall be bankrupt."—*The Glasgow Herald*, November 8, 1917.

† "Scientific Management" and "Shop Management," both by F. W. Taylor.

thoroughly and earnestly down to the smallest detail. "Square pegs are not put in round holes." A few firms, where apprentices are concerned, are inaugurating schemes which promise great benefits for the future, and these schemes follow the same broad lines as the most advanced methods of scientific management.

4. The reactions of environment, and the limitations of fatigue are studied in minute detail, and no overstrain is allowed. In connection with environment, the bad lighting of many shops involves strain and depression, and undoubtedly restricts output. For instance, with marking off work on surface tables the intensity of light is often quite inadequate. The amount of illumination that is required is well known, and the quantity that is provided can easily be measured. Illumination, in other words, is an exact science. For heating some of our shops in winter time, open fires are the only means provided, and with many types of work, such as attending machines, the unevenness of temperature tends to poor and inadequate work. Work can, with a little forethought, generally be arranged to be placed in correct location to the worker for maximum efficiency. Where seating accommodation is necessary this can be designed with a view to minimum fatigue. Control handles of machines can be arranged for the most convenient operation. These are only a few of many instances which might be given if time permitted.

5. The worker is encouraged and recompensed by a system of payment by results. This subject will be fully dealt with later.

From the foregoing brief outline it will be seen that the functions of management are greatly extended as compared with the present practice. Facts replace impressions. For the main outstanding facts relative to the performance of any given works, recourse must be had to the costing department. The value to be put on the figures produced depends entirely upon the efficiency of the costing arrangements, which should be designed to afford information, making possible the fixing of a satisfactory selling price, the differentiation between the type of work which pays best and that which does not pay, and the indication of leakages and rates of expenditure above normal as soon as possible after such occur. The costing arrangements in this country are generally so inadequate that jobs appear on the books at a profit, whereas, in fact, they were carried out at a loss. This misrepresentation is due primarily to faulty allocation of wages and incorrect proportioning of charges.

Apart, however, from these broad points, there are many detailed considerations, to which due attention must be given. In order to indicate the lines of desirable progress there is required an accurate appreciation of the total cost, including wages charges, &c., for each job, and consideration and trial of alternative methods—amongst others the range of utility of various tool steels, coolants, forms of cutting points, &c.

The lack of consideration in regard to the relation of time occupied and wages paid to the total cost of any operation or job is considerable. It would be well to know how much extra cost is incurred on large contracts owing to the work being put through the shops in an order incompatible with the best overall results. This is apart altogether from the influence on the progress of work of badly timed deliveries of raw materials where these cannot be controlled. Again, much time is wasted by workers having to wait on cranes, labourers, helpers, appliances, &c., due to shortage of tools, jigs, fixtures, or actually "waiting for work," although in the same shop, where a considerable and avoidable amount of time is lost waiting for work, it will be found on investigation that overtime is generally worked to make up for this lost time in waiting.

The last item of the scheme (No. 5)—payment by results—is put in its proper order. No move should be made in the introduction of the system until the works have been organised, the plant studied, amended, and added to as necessary, the methods and inspection standardised, and the training systematised. If this procedure be rigidly adopted, the tendency to the cutting of time will be minimised to such an extent that a simple system can be evolved to achieve the maximum efficiency. Under such conditions it is not necessary to consider systems whereby the effect of an excessive basis time or time limit needs to be counteracted by having a graduated scale with the consequent lessening of incentive and restriction of output. The relative position in the scheme of organisation, and the method of working any system of payment by results are of as great, if not greater, importance than the details of the system itself.

At the present time payment by results is regarded as a panacea for almost all evils. Several ill-considered schemes have been put into practice because they can be described as systems of payment by result; they meet with sufficient approval, and cannot be said to be directly provocative of trouble. In extenuation of such procedure, it is claimed, for instance, that a certain scheme may not actually be the best, but that it can be adopted immediately, and will show a gain in output and a reduction in cost, and as such will help to win the war. This is very true; it helps to win this war; but it may become a factor in tending towards losing the next war—the industrial war. Careful balance is necessary between that which has immediate benefits and that which tends best in the direction of future industrial prosperity.

Systems of payment by result automatically grade labour: but the tendency has been that the reward for repetition work is out of proportion to that which can reasonably be earned by the skilled worker on jobs of widely varying natures: whereas, of course, the idea is for equal degrees of skill and energy to have the same amount of remuneration. To some extent this lack of balance can be counteracted by specialisation, where this is not undesirable: but under scientific management the grading is accomplished by means of comprehensive tests, and the total payment for a given function of work bears its true proportion to the total cost. The making of these tests helps to secure further the most desirable result that the knowledge of a few is diffused among the many, with gain in overall production.

The objections raised to the system may be subdivided under two broad headings—those of the employed and those of the employer. Consideration may first be given to the workers' attitude:—

1. There is a natural opposition to all things new, following the inherent inertia of the average Britisher who is unwilling generally to admit that a better way can be devised than that to which he has been accustomed. This has only to be stated to show that it is untenable.

2. Many workers of considerable skill in their particular craft are disinclined to divulge to apprentices or even fellow-workers, the methods by which they attain success. It is objected that the grading of labour applied satisfactorily in certain districts entails the making of tests. If the period of apprenticeship is to be shortened, as generally it may well be, the time will be governed by the progress made and the knowledge gained, which can only be gauged satisfactorily by tests. With increased education a clearer knowledge of economic truths, and a fuller realisation of the duties of citizenship, the objection to tests may diminish.

3. The advance of modern thought demands an ever-extending amount of repetition work done to precise measurements, and the extended use of labour-saving machinery and appliances. The consequent changes are the root cause of the principal objections of craftsmen to the whole system of industry to-day. The application of machinery is compelled by forces which it is impossible to resist, and attempts at retardation can only produce waste, friction, and loss. It is stated that machinery tends to produce the automaton, and to make for monotonous conditions of work. Scientific management, which is often charged with turning men into automatic machines, accepts the inevitable—the introduction of machinery and schemes and studies in order to prevent that which it is erroneously charged with creating. How? By ensuring for all the fullest possible chances of being allocated to that work for which they show the greatest suitability and adaptability, and in doing which they can gain the highest earnings for their efforts and ability; and by the improving of the working conditions and the training of the operator, in order to achieve maximum utility in the sphere of work, without waste of effort or overstrain. The rate of output attained should ensure more leisure time, and more reserve effort, mental and physical, for recreation and a fuller life. If the spare time be usefully employed there will be developed more self-respect, which is the surest basis of all improvements. Irrefutable evidence has been obtained with repetition war work that the output can be increased, with improved working conditions, higher rates of pay, and less hours of work.

4. The question of systems of payment by results is a large one. Possibly in the United States of America this side of scientific management has been overdone. Efficiency experts have delighted in constructing somewhat elaborate curves of bonus for various types of work, and employers there have been guilty of the great economic blunder of taking to themselves too large a proportion of the efficiency award. Let it be emphatically stated at once that scientific management does not mean any particular system of payment by results, but demands that before the question of efficiency award is raised, the conditions shall be improved, tests applied, and standards framed, so that, as already pointed out, objections to such payment are greatly lessened when they are part of a scheme of scientific management. These objections are, briefly;—

(*a*) The lack of a guarantee that the price or time fixed for a given job will not be altered except the materials or the method are changed—in which case it is admitted on all hands that the basis must be reviewed—and that when such change takes place the new rate will bear the same relation to the whole that the work involved with the improved or altered method does to the original amount. This applies to all systems of payment by results.

(*b*) The employer takes too large a proportion of the gain accruing from increased effort. This applies only to the bonus systems, and particularly to certain schemes.

As to the former (*a*), with the broader outlook advocated, the cutting of rates should be a rare occurrence. The tendency, however, is still inevitable in order to prevent excessive cost. This statement may seem fallacious in respect that whatever the wages cost, charges have been saved by the reduction in time which economists assume is always a real reduction relative to the time work and not an apparent reduction. Generally they have little experience of shop conditions, and the reason for excessive cost may not be obvious. When under observation for the purpose of fixing bonus time or piece rates, workers notably try to mislead as to the rate of work of which they are capable, and are successful sometimes in getting such a basis that they can make a large bonus when working no faster than when on time (which is a faster rate than when under observation) and an exceedingly large bonus when working at maximum intensity. The basing of times or prices on insufficient data, or on careless observation, is sometimes responsible for excessive bonus and costs, including charges, which may be higher than when the job was done on time wages, and the excessive bonus involves the inevitable dissatisfaction on the part of fellow-workers. Careful and scientifically-conducted time studies are consequently necessary in order to prevent this dangerous state. Collective bonus or piece-work systems are advocated to level up the earnings, and so cover up blunders, and this cannot be considered as a solution, because, in addition to other disadvantages, one of which will be referred to later, the functions of management pass with such schemes to the workers, and the incentive to individual effort is greatly lessened.

There still remains with all of the systems the question of guarantee, and this can only be solved by co-operation between representatives of the employer and the employed, where the original investigations and time studies are concerned. This is being done in some industries, and goes far to mitigate the greatest objections to systems of payment by results.

The carrying out of time studies is only one of the elements of scientific management, and, for the best results, should be undertaken by a highly-trained staff practised in the art of observation, scientifically equipped with the appliances requisite to record the observations and able to equate the various data.

5. It is stated that scientific management entails the elimination of all but the most efficient, and as such it is condemned.* This is an expression of opinion based, judging from the context, on an incomplete knowledge of the first principles of the system. Every quest for efficiency, including systems of payments by results, must throw into contrast, and must differentiate the most, from the least, efficient; but this is inherent to all sound economic principles. Take as an example the contract system, when a worker as contractor takes on a contract—that is, undertakes a certain definitely specified job at a contract price. He will generally desire to choose his own men, and will request the management to find other work for such as he considers to be least efficient. This point is rather an interesting one, and affects collective bonus, to which reference has already been made, in that the failure of the individual with collective bonus is not so likely to be brought to light as with the contract or individual bonus systems. Without some system for training these least efficient members, efficiency means their ultimate elimination; and this training and absorption is a part of the system of scientific management.

Many objections are still raised by employers, especially those who have little experience of payment by results, and to these reference may next be made:—

1. It is contended that the staff required by scientific management, each member of which has a definitely specified function, is larger than is needed merely to fix rates accurately. Again, it is asked where is such a staff to come from? Certain it is that, until there is a demand, there will not be any supply. If there be the demand the staff can be created if our technical colleges are encouraged in this direction. It is from such sources that we must turn in the future for our staff officers. It is admitted that a large staff means increased charges or overhead expenses. This bare fact is regarded in many quarters much more seriously than a corresponding increase in direct wages, and is encouraged by the terms of time and lime contracts so much in vogue to-day. Generally the works with the highest actual charges due to managerial efficiency produce most cheaply. An increase of staff also brings encouragement and incentive, widens the field of promotion, and gives a desirable reward for ability.

2. The fact that scientific management originated many years ago in the United States of America, is considered sufficient excuse in some quarters for condemnation without investigation, although those who express such opinions have probably failed to realise that conditions of wages in this country are approaching those which prevail in America.

3. Sometimes the first principles of scientific management are approved, but are considered to be applicable primarily to repetition work. It is unnecessary to remark that this statement is made by those who claim to have little or no such work in other shops. On analysis, it will generally be found that there are quite a sufficient number of jobs of this nature to merit the courage of conviction; and the results of a trial, if carefully conducted, will probably lead to extension of effort and a broader application.

4. The amount of system required to carry out such a scheme as scientific management it is urged leaves scope for objections because of possible complication and fears for abuse in practice. Costs engineering, planning, routing, progressing, rate-fixing, and functional foremanship, are all included, and the question arises as to whether the results justify the seeming complication. Fortunately, considerable proof in their favour is now available. If, however, carefully collected data relative to the cost of wastage of time and of materials in an average works could be scrutinised—and this information will not easily be collected—the risk of expending a certain sum in an endeavour to save a multiple thereof should surely be taken.

It will be noted that so far no mention has been made of "Motion Study" which, although associated inseparably with scientific management, has, in descriptions, been exaggerated out of its true proportions, and in discussions has been ridiculed. One example only will be given, that of the Gilbreth system, as being applied to-day in several quarters. The worker in this case is a disabled soldier, the operation walking, and the appliance an artificial leg. By means of "motion study," conducted on the most modern principles of scientific management, and, by applying the results of the investigation, the operator can be saved each step much energy and discomfort. There are many similar repetition motions in industry to-day often capable of considerable improvement. The efficient absorption into industries of disabled soldiers almost demands the application of the following: Determination of desired qualities and selection of suitable workers; adaptation of the plant; training

* Trans. Engineers and Shipbuilders in Scotland, vol. lx, Part II, page 14.

of the worker; study of fatigue—all of which have been dealt with.

To sum up, Mr. Michael Longridge* may be quoted—"Except in a few cases," he declared, "workshop organisation here has not received the attention given it in America or Germany. There are still shops without definite planning of the progress of the work, without adequate equipment of jigs and gauges, and without standard shapes of tools, or a tool-room: where men drift about in search of tools or tackle, or wait in idleness for drawings and materials: where machinery is obsolete and light so bad that good work cannot be done if the machinery were up to date. Such shops must go. They cannot compete in price or quality of work with those in which what is known as "scientific management," or anything approaching it, prevails; where the progress of every job is planned to the last detail before it is sent into the works; where labourers and tackle for fixing the work are ready the moment they are wanted; where drawings, gauges and tools properly ground to standard shapes come with the work; where cleanliness, light and comfort reign, and where endeavour is made to get the workman to regard his job more as a problem to be solved than a task to be got through." No better summing-up can be given.

At the present time there is a decided move towards an early realisation of the desire to put first principles into practice. Co-operation towards industrial research is generous and active, and the training of apprentices is being considered and undertaken earnestly and on broad lines. Those movements point to a future wherein first principles, when accepted in theory, will not be so often neglected in practice.

It is true that the scheme of scientific management may not be immediately applicable in its entirety, especially in works where tradition has tended to an undue prolongation of practice inconsistent with modern ideas and modern mechanical methods. It is always difficult to make radical changes successfully. The introduction of scientific management in all its completeness may involve an upheaval which is not to be lightly advocated owing to its ulterior effects, but a beginning should be made. The author in this paper has tried to raise discussion on the broad principles in the hope of stimulating reorganisation on carefully considered co-ordinate lines rather than by sporadic efforts.

It is desirable that all and not only some of the works managers of to-day, and those responsible for the works, should by study of first principles become alive to the potentialities of the fundamental features of the system of scientific management—the full utilisation of latent faculties.

Instead of a levelling-down process, its ideal is not alone to increase productivity, but to advance personal efficiency. No single measure can realise all our hopes, but the principles advocated here tend to reduce individual fatigue, develop higher intelligence, open up a broadened outlook, afford greater leisure, and bring more scope for a fuller life. Industrialism is in the melting pot, and the present gives an unparalleled opportunity to mould it anew.

Steam Boilers Utilising Melting Furnace Waste Heat.—We read in *The Iron Age* that after investigating various kinds of boilers, including horizontal, marine and others, the Danville Malleable Iron Company, Danville, Ill., selected an upright water-tube boiler as best suited for the utilisation of waste heat from two 20-ton melting furnaces. That the floor space required was comparatively small was an important factor in determining the choice. A 250-h.p. boiler was, at first, estimated to be of sufficient size, but because of what might be called a superheated gas after it had passed over a bath of molten metal, and because of its velocity, greater capacity was deemed advisable, and a 400-h.p. boiler was finally selected. To get constant results from the boiler and maintain constant steam pressure, it was thought best to have two furnaces and an auxiliary fire-box connected with the boiler. By running the furnaces one at a time, a full head of steam can be kept on the boiler, except for intervals during the changing of the furnaces and for a short period while the cold stock is being thoroughly heated. This takes care of all firing for at least 9 hours a day; during the balance of the day, the boiler can be kept under pressure by a small fire in the auxiliary fire-box. One furnace is operated while the other is being repaired. Temperature control in the furnace and the efficiency of the boiler can be aided by the addition of an induced-draught fan in the base of the stack. The temperature in the base of the stack is about 800 deg. F., and that at the back bridge-wall of the furnace about 2,500 deg. F. This equipment evaporates about 246,000 lb. of water per day, using in the auxiliary fire-box from 1 ton to 3 tons of coal. The article from which we quote gives particulars as to the best location of the boilers with regard to the furnaces, and adds that the water supply should be absolutely assured; two independent sources of supply should be provided, and all piping and valves should be extra heavy and erected with care. The most desirable service is by using the waste-heat boiler in conjunction with a battery of hand-fired boilers, the steam pressure to be equalised and balanced by their use. The waste-heat boiler requires constant attention. A 400-h.p. boiler connected with a 20-ton furnace operating at capacity will produce steam at full capacity, or a little in excess, after the metal has been reduced to a semi-fluid state, or for 8 or 9 hours per day. There is no noticeable effect on the furnace operation; in fact, the furnace is operated without regard to the boiler connection.

* Presidential Address to the Institution of Mechanical Engineers, April, 1917.

WOOD SHIPBUILDING IN THE GULF STATES.

*Shipbuilding in the Gulf States and the Natural Resources and Facilities Favourable Thereto.**

By Charles N. Crowell, Member.

The writer of this paper has for years been interested in the great natural resources and facilities favourable to shipbuilding in the Gulf States. It was when the United States Shipping Board asked for 1,000 wooden ships that the idea at once presented itself—how large a quota of this could be supplied from this southern country? The Pacific Coast can, of course, well do its share. The Atlantic States, however, are entirely dependent on the south for this timber supply. As to the 1,000 ships, in the writer's opinion, that is not an impossible proposition—it depends on proper organisation and a reasonable period of time.

The yellow pine timber supply of the south is furnished principally from the States of Mississippi, Louisiana and Texas. Of course, other states furnish a certain proportion, but the best of all is from Louisiana and the best of Louisiana is from Calcasieu Parish. The Calcasieu long leaf is the best shipbuilding timber in the world and the supply of that, taken in connection with what is furnished from adjacent parishes and counties, is sufficient to meet all reasonable demands for years to come. In riding through this territory over the lines of the Iron Mountain, Santa Fé, Kansas City Southern and other roads, one passes through hundreds of saw-mill towns and thousands of acres of virgin pine; and in the river bottoms, Sabine, Neches, Trinity and Brazos, large forests of hardwood are available, containing the oak timber for vessel framing. The writer has ridden by team through oak forests in North Louisiana, 20 miles to 30 miles across, on which stood millions of feet of the finest oak timber. This is the supply, and close at hand to the builder in the Gulf States, with the advantage of quick delivery and low freight rates. And not only is this true of vessels of wood, but the facilities for building steel ships are also available. In East Texas, in the region adjacent to Beaumont, there are very extensive areas of iron ore. Plans are already being formed to develop this ore and will probably be put in shape in the near future. Smelters and rolling mills and fabricating plants will be established and steel ships will be a product of the south. As it is now, several contractors are considering the importation of fabricated steel with which to build steel and composite ships. This supply would come from Birmingham, Memphis and St. Louis. The important factor, fuel oil, is found all through Texas and Louisiana, as is well known. The shipyards of the north, from Maine to Virginia, have, of course, many long-established plants, and history has told us of the days when American-built wooden ships, masterpieces of the great designers, George Steers, Donald Mackay, William H. Webb, and many others, were unexcelled on the high seas.

Answering to the great unprecedented demand for tonnage, all these plants—all regular shipyards—were naturally soon filled with orders. It remained to seek further for places to build, and the response has been generous. Shipbuilding plants have sprung up all over the south, many there are which six months ago were covered with forest growth. The trees were cut and stumps removed by dredge boats, and the suction dredger raised the grade to the desired height. Many of these plants to-day are well equipped, containing all modern labour-saving machinery and, in the district lying west of the Mississippi River, at least 150 vessels are building and contracted for.

Some of our northern plants may well profit by what is being done in the south. The facilities which they are introducing will insure rapid and economical work. Some of the men who are operating the various new shipyards have never built vessels, but, what is more important, they are men of executive ability, who know how to make up an efficient organisation. These same men, some of them entirely without shipbuilding experience, have gone ahead, taken contracts, selected their sites, cut off the trees, graded their yards and installed equipments, chosen their department heads, and are building ships and building them well—as economically as many old-established plants which have been building ships for years. One yard in Texas is to-day building 14 wooden steamships, 4,700 tons deadweight capacity, completely equipped with machinery and everything ready for sea. So far as I know, these are the largest wooden ships in the world, in fact, the largest ever built. And there are four other yards in this same town, ideal ship sites. Much has been said of building ships of green timber. In all the writer's experience, never has he seen a vessel built of any other except in the case of small craft, such as launches, or in the selection of decking and planking more or less seasoned. The timbers and framing of a ship are generally cut to order and not carried in lumber yard stock.

Summarising—the south not only has the material supply, but she has it close at hand; already many building plants are well established and there are available sites for many more. Any kind of a ship and any integral part of a ship may be produced in this southern country. And the men here are capable of producing satisfactory results. In these days of improved wood-working machinery, the skill of the shipwright, once the autocrat of his trade, is largely supplemented, and compressed air now does most of the work of fastening, which forms a large percentage of shipyard work. There is in these days no more of that heavy lifting common to olden times when it was customary to summon, "All hands to raise frame," or carry a 40-ft. oak deck beam on men's shoulders up the brow stage of a three-deck ship. The wooden shipyard crane or derrick does all that, making a saving in time and money. Another advantage of this southern country is the small percentage of time lost. The winter climate is delightful, and the summers, while they are longer, really do not attain to much higher temperature than is reached in New York City. There is one shipyard starting in Morgan City, Louisiana, on the banks of the Atchafalaya River, 82 miles west of New Orleans. This is a beautiful location with a natural sloping grade, just right for a shipyard. Three months ago this was a sugar-cane plantation.

A bridge-building concern came along, saw the place secured a contract for six 300-ft. wooden steamships, and to-day that cane-field has been changed into a modern, well-equipped shipbuilding plant. Speaking of oak ship frames, it has been the custom for years for Maine builders to bring their moulds, or patterns, down to the oak forests of Maryland and Virginia and hew out oak frames, keels, stems and sterns, thereby obtaining natural crooks, which greatly strengthen a vessel. This is still being done, although the forests of the eastern States are well nigh exhausted. But the south can supply these oak frames for many years yet. While much yellow pine is used for framing, the necessary wide flitch timbers are cross-grained and afford but little strength; however, in this time of need, all sources of supply must be requisitioned, oak and pine, wood and steel. All kinds of ships will be needed. No one will dispute the fact that a steel ship is superior—that is self-evident.

It has been said that so many wooden vessels being built now will be practically useless should the present war terminate and peace be declared—these wooden vessels could not complete with foreign steel freighters. Probably they could not, but they are necessary at the present time, and can be used afterwards as coasting vessels and to carry freight to Central and South American ports.

At this time the number of ships possible of production is the vital question, and the southern States can and will produce their quota. From Tampa to Corpus Christi our people are striving to do their part.

* Paper (slightly abridged) read at the meeting of the Society of Naval Architects and Marine Engineers, in New York, November 15.

Swedish Industrial Activity.—A syndicate, including the large Uddeholm Company, has secured some newly-discovered coal deposits in West Gothland, for which Norwegian capital was also in the market. The quality of coal is not superior to the West Swedish coal, but the deposits contain vanadium, which Sweden hitherto has been obliged to import from America for the manufacture of its high-grade steel. The vanadium will be rationally dealt with by the Uddeholm Company. At the instance of the Swedish State Industry Commission, the manufacture of sewing cotton and yarn will be taken up in Sweden on an extensive scale, and the production, which promises to be good and at reasonable prices, will promptly be offered to the public. At Norrköping, a large factory will be started for wool-cleaning and the manufacture of certain yarns which have hitherto been imported from Germany. The Swedish textile industry has been seriously handicapped during the war from shortage of raw material. A company has been started for the manufacture of motor ploughs according to a new design, and for the manufacture of other agricultural machines. The Separator Company, Stockholm, has again increased its capital from 42,000,000 kronor to 63,000,000 kronor. The company's net profits for last year amounted to 10,771,000 kronor, against 6,729,000 and 4,380,000 kronor, respectively, for 1915 and 1914 (18 kronor= 1*l.*)

"The Motor Manual."—The twenty-first edition of this manual is now available. It is compiled by the staff of *The Motor* and is published at the price of 2*s.* net by the Temple Press, Limited, 7 to 15, Rosebery-avenue, E.C. 1. The first chapters deal with the working principles of the internal-combustion engine in its various types, carburation and ignition; then follows a detailed consideration of all the constructional features of a car, beginning with the clutch, thence the gear-box, rear axle and wheels, so that the reader obtains a sound conception of the fundamental principles of a car. The descriptions of engines range from a two-cylinder to the latest developments in eight and twelve-cylinders. Numerous excellent illustrations are given of all representative types of engines, which greatly help the reader in following the text. A number of improvements have been made in the chapters dealing with ignition, and the latest magneto developments are included. Electric lighting and starting are dealt with in a comprehensive way, which does not presume any previous electrical knowledge on the part of the reader. Here, again, the text is greatly assisted by a large number of clear illustrations of dynamos, electro-motors, auxiliary appliances and arrangements of car wiring circuits. Wheels and tyres are dealt with in detail and much new and useful information is given on the question of how to obtain the greatest mileage from a set of tyres, and carry out all the necessary repairs, including the use of a vulcaniser. Information will also be found on the principles underlying the driving of a car. Simple motor repairs, adjustments and home workshop operations have always proved a popular and useful feature of the Manual, and new illustrations have been added. A feature of the present edition is the treatment of the question of fuels other than petrol.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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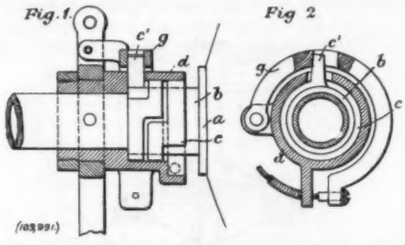
AERONAUTICS.

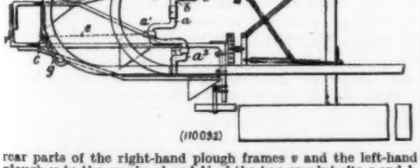
109,991. T. J. Connor, Failsworth, near Manchester. Landing Chassis. (6 *Figs.*) September 27, 1916.—This invention relates to the landing chassis of flying machines of the kind in which the landing wheels are provided with band brakes, controlled by the airman. According to the invention, the landing wheel hubs *a* are provided with tubular extensions *b* on the inner sides, which revolve within relatively fixed casings *d*. Within each casing and between the same and the respective



tubular extension is a substantially spiral-shaped band *c*, one end of which is anchored to the casing, while the other end c^1 projects through an opening or enlargement in said casing, and is acted upon by a manually-controlled member *g* so as to cause it to tighten the band *c* on the tubular extension *b*, the band being so arranged that immediately it grips the hub extension the rotary movement of the latter tends to wrap said band more tightly thereon, thus causing a powerful braking effort, with a minimum force required to control same. (*Accepted November* 17, 1917.)

AGRICULTURAL APPLIANCES.

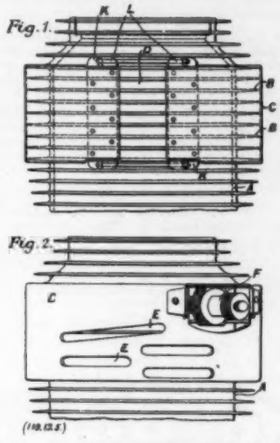
110,032. F. M. Waller, Stafford. Mechanically-propelled Ploughs. (1 *Fig.*) October 11, 1916.—This invention relates to mechanically-propelled ploughs of the one-way type. According to the present invention, two ploughs are arranged side by side at the rear of the tractor, and each of the ploughs is suspended from the tractor fore and aft, the points of forward suspension being practically constant, and those of the rear suspension being adjustable transversely. Each plough is provided with any suitable lifting tackle, by means of which, when the plough is lifted, the front share or shares leave the ground in advance of the rear share or shares, and when the plough is lowered the front share or shares engage the ground in advance of the rear share or shares. The crankshafts *a* and *b* of the two lifting tackles are arranged in axial alignment. The pulleys *c* and *d* over which the chains *e* and *f*, which respectively connect the



rear parts of the right-hand plough frames *v* and the left-hand plough *w* to the cranks a^1 and b^1 of the two crankshafts *a* and *b*, are mounted to rotate on, and to move axially in respect of fixed, transversely-arranged shafts *g* and *h*, carried by brackets fixed to the frame of the tractor. When either of the ploughs, for instance plough *v*, is in use, the pulley *c* of its lifting and suspending tackle lies at the inner end of its shaft *g*, but when either of the ploughs, for instance, plough *w*, is out of use, its pulley *d* lies at the outer end of its shaft *h*. When the plough *v* is swung out of its central or working position it occupies the same position—on its side of the main frame of the tractor—as the plough *w*, which allows said plough *w* to be swung into its central or working position. The front parts of the frames of the two ploughs *v* and *w* are connected to the cranks a^2 and b^2 by chains. (*Accepted November* 17, 1917.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

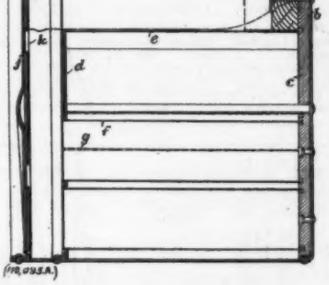
110,125. A. T. Simpson, Hull. Internal-Combustion Engines. (6 *Figs.*) June 9, 1917.—This invention relates to apparatus for cooling the cylinders of rotary internal-combustion engines of the kind which are used on aeroplanes. This invention comprises a metal casing surrounding the radiating fins on the engine cylinder and provided with openings at the front and back for the air to flow in and out. A is a cylinder with radiating fins B, and C is a light sheet-metal casing surrounding the fins, thereby forming channels between the fins along which air can circulate. The air is admitted at D, in the front of the cylinder, and escapes at the back through openings E. The latter openings are disposed so as to equalise the cooling and prevent distortion and are preferably staggered on each side of the centre line in order to ensure that the hottest point in any channel shall not coincide with that of the adjoining channels. Where a sparking plug or other device protrudes from the cylinder, provision can be made to circulate air around it. F is a sparking plug, and the casing is cut away to allow air to escape at this point. To

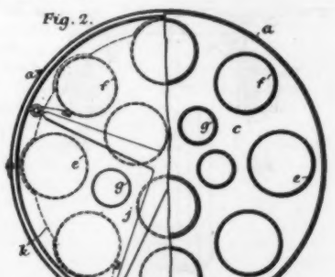


secure the casing in position on the cylinder its ends may be folded over to embrace metal strips which extend beyond the casing at the top and bottom to form cars K. The strips are secured to the casing by rivetting, and the cars are drawn together by bolts L. (*Accepted November* 17, 1917.)

GUNS AND EXPLOSIVES.

110,095. T. L. Squires, Edgbaston, Birmingham, and The Metropolitan Carriage, Wagon and Finance Company, Limited, Saltley, Birmingham. Ammunition Conveyors. (3 *Figs.*) February 15, 1917.—This invention comprises an improved container of the cylindrical type for shells and the like, and consists in the combination with a drum having a fixed end-plate and a false end-plate perforated for the reception of a nest of individual pieces of ammunition, and a suitable removable closure device, of a number of tubular receptacles extending between the fixed end-plate and the false end-plate in line with the aforesaid perforations for enclosing the individual pieces of ammunition. *a* is the drum and *b* a fixed end-plate within which a lining *c* of wood is secured. A short distance from the open end of the cylinder is a false end-plate *d*, and a number of tubes *e*, *f* and *g* are secured to this plate *d* with their other ends received

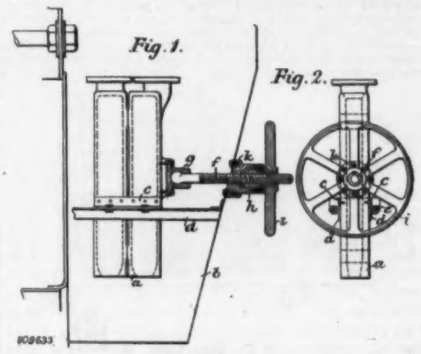




in annular grooves in the lining *c*. Beyond the plate *d* is a space, and the open end of the cylinder is closed by a removable end-plate *j* which may seat against an annular flange *k*. This removable end-plate is preferably lined with leather or provided with rings or pads of same to engage the ends of the articles, as at *l*, when within the tubes. The tubes *e* are for the shells, and *f* for the cartridges or charges and *g* are for the fuses. The shells, cartridge cases and fuse cases project from the tubular pockets in the space between the plate *d* and the removable end-plate *j*, so that they are easily removed and inserted. With this device in use the shells, cartridges and fuse cases may be inserted, and the drums may be slung on to and conveyed by trucks or vehicles and may be readily slung off and trundled by hand where desired; the cylinders being more convenient for trundling than the separate shells and enabling more ammunition to be taken forward at each journey. (*Accepted November* 17, 1917.)

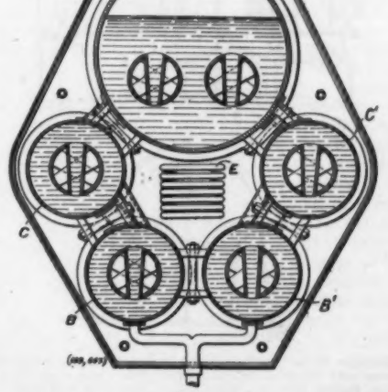
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

109,633. R. S. Portham, London. Superheating Apparatus. (4 *Figs.*) August 4, 1916.—This invention relates to superheating apparatus for boilers of the fire-tube type. According to the invention, the headers to which the superheater tubes are attached are so mounted as to be capable of adjustment relatively to the boiler plate so that the superheater pipes attached thereto may be inserted or withdrawn more or less from the fire tubes. *a*, *a*, are headers respectively for saturated and superheated steam, and mounted adjacent each other in the uptake *b* of the boiler, one header being disposed in front of the other and parallel to the fire tubes. The headers are connected together by means of angle irons *c* and are supported upon horizontal supporting members *d* which are connected at one end to the front of the smoke-box and at the other to uprights (not shown) supported from the bottom of the smoke-box. The angle irons *c* are preferably disposed at or near the mid



position of the length of the headers, so that the headers are substantially balanced. When the headers are in the desired position, the angle irons *c* are fastened to the supporting members *d* by bolts, holes being provided in the supporting members *d* for the bolts at the various positions in which the headers may be placed. In order to alter the position of the headers, and thus alter the position of the superheater pipes connected thereto with regard to the fire tubes, a screwed rod *f* is mounted upon the forward header by means of a ball joint *g*, and the end of the rod is passed through a hole in the front of the smoke-box. A nut *h* is threaded upon the screwed rod, and is attached to a wheel *i*, whereby the nut may be conveniently manipulated. The nut is disposed within a housing *k*, which is bolted to the smoke-box plate, and is prevented from moving longitudinally relatively thereto. It will thus be seen that, after the bolts have been removed, on rotating the hand wheel *i*, and thereby the nut *h*, the screwed rod will be caused to move longitudinally, and thus draw the headers *a*, *a*, away from the boiler plate, or *vice versa*, according to the direction in which the nut is rotated. (*Accepted October* 3, 1917.)

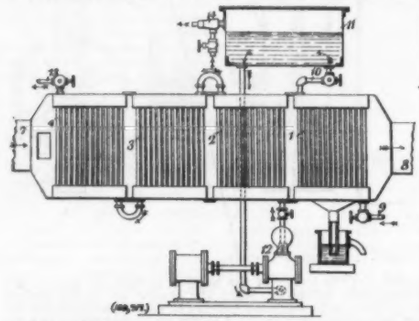
109,647. T. E. Halliday, Bishopstoke, Hampshire. Steam Generators. (3 *Figs.*) September 18, 1916.—The present invention relates to boilers or steam generators of the type having separate vessels or compartments, each adapted to be heated and so arranged that the water passes through each of the chambers in turn, and being heated therein is raised to a successively higher temperature in each and finally vapourised in the last chamber. This invention consists of a steam generator comprising the combination with a single steam-forming vessel D, of two or more series of water-heating vessels B, B_1, C, C_1, arranged in parallel and communicating therewith, wherein each



of the vessels B, B_1, C, C_1, D, is provided with an internal flue or flues containing a fluid-fuel burner for heating that vessel. An important feature of the invention is that the connections between the various vessels are such as to prevent or minimise circulation of the water between the different vessels, and to permit only a flow of water, according to the consumption of steam, from the feed-water inlet towards the steam-forming vessel D. Preferably the various vessels themselves are so formed as to promote local circulation of the water in each vessel. According to another feature of the invention, additional connections may be provided between the various vessels so arranged as to permit one or more of the water-heating vessels

to be by-passed or cut out of the series when desired. This feature is provided with the object of allowing the boiler to be maintained in service although one or some of the elements may be burnt out or otherwise rendered unfit for use. The various vessels constituting the boiler are preferably cylindrical in form and arranged with their longitudinal axes substantially parallel, and they may be disposed around a central space in which a superheater E for the steam is provided; this central space may be used as an outlet flue for some or any of the combustion gases from the various vessels or a separate burner may be provided if desired. (*Accepted October* 3, 1917.)

109,717. Babcock and Wilcox, Limited, London (*The Babcock and Wilcox Company, New York, U.S.A.*). **Steam Boiler Economisers.** (11 *Figs.*) December 28, 1916.—This invention relates to steam boiler economisers of the type wherein the feed water is heated in a low-pressure stage, is then taken away from the heating apparatus, air or other gases allowed to escape therefrom, and the water then fed, preferably by a pump, to a second stage of the economiser under boiler pressure. In an economiser, according to the invention, the features above admitted to be individually old are combined, *i.e.*, there are combined three features, namely, formation of the economiser in stages subject to different pressures, provision for the removal of air or gases between the stages and construction of the stages of different materials. 1, 2, 3 and 4 designate sections of an economiser arranged in series. The flue gases enter at 7,



and after flowing over the economiser tubes leave through the flue 8. The cold feed water enters through a pipe 9, connected to the lower box of the economiser section 1, and upon leaving the same, flows through a pipe 10 to a tank 11. From the latter the water is forced, by a pump 12, through the sections 2, 3 and 4 of the economiser, and finally leaves the economiser through a pipe 13. In this arrangement, the hot gases first pass over the section of the economiser containing the hottest water, and the cold water enters the section exposed to the coldest gases. The tank 11 may be open so that the water therein is under atmospheric pressure, or the tank may be closed and the space above the water connected to an ejector 14 for maintaining the pressure below that of the atmosphere. As the cold water flows through the tubes of section 1 it will be heated by the gases to a sufficient temperature to expel the air therefrom, the air escaping when the water is delivered to the tank 11. (*Accepted October* 3, 1917.)

110,146. K. Baumann, Barnfield, Urmston. Axial-Flow Steam Turbines. (8 *Figs.*) October 31, 1916.—This invention relates to steam turbines of the axial-flow type, in which the volume of steam leaving the exhaust blades is considerable, and consequently the exhaust casings and outlets are of considerable size. The turbine is, according to this invention, provided with means for introducing a limited degree of flexibility between the overhung portion of the cylinder and the exhaust casing, which is directly supported from the foundations. 14 is the turbine cylinder and 15 is the exhaust casing. 16 is the bearing pedestal for the shaft bearing at the high-pressure end of the turbine, 17 the shaft bearing at the low-pressure end, and supported, as shown, from the lower half of the exhaust casing 15. The exhaust casing is provided with a

Fig. 1.

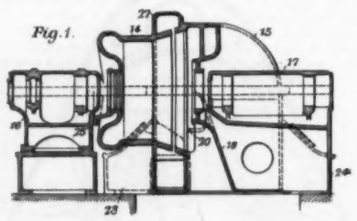
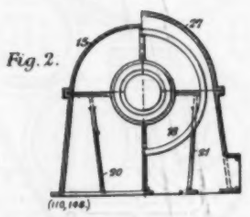


Fig. 2.



diaphragm 18, the upper edge of which extends across the exhaust casing near the final row of moving blades, and separates the steam flowing from the upper half of such blades through the exhaust casing from the steam flowing from the lower half of such blades through the exhaust casing. The lower half of the exhaust casing is provided with two internal webs 20, 21, extending across the exhaust casing in a direction substantially parallel with the turbine shaft and the turbine is supported in position, on its foundations by feet 23, 24, located respectively at the high-pressure and low-pressure end of the exhaust casing 15. The overhung portion of the cylinder is connected at the high-pressure end by a semicircular portion 25, with the pedestal 16 supporting the shaft bearing at this end. The desired flexibility between the overhung portion of the cylinder and the exhaust casing is introduced by circumferentially dividing of the turbine cylinder 14 near the exhaust casing 15, so that a portion of the cylinder 14 is separated from the exhaust casing, and by surrounding the circumferentially-divided portion of the cylinder by an expansion belt 27. The webs 20 and 21 are as shown in the right-hand half of Fig. 2, continued through the lower portion of the expansion belt 27, and where they join the upper portion of the supporting feet 23 constitute a fixed point between the exhaust casing 15 and the overhung portion of the turbine cylinder 14. Such a fixed point is necessary in order to provide sufficient rigidity to prevent expansion of the turbine in an axial direction. All other points on the periphery of the cylinder 14 are, however, capable of a limited amount of movement, and should vertical expansion take place the two divided portions of the cylinder surrounded by the expansion belt 27, at the upper half of the turbine, will be caused to separate, and at the bottom half to approach each other. In this way the exhaust casing 15 and its supporting feet 23 may expand in a vertical direction without causing the bearing pedestal 16 to be raised from its bedplate. (*Accepted November* 17, 1917.)

TEXTILE MACHINERY.

108,684. H. F. Anderton and G. Bailey, Bradford, Yorkshire. Drying Yarn. (3 *Figs.*) September 13, 1916.—This invention relates to apparatus for drying hanks or skeins of yarn wherein series of hollow-perforated rollers *a* are made use of, the same being situated within an enclosed chamber and having travelling bands or tapes *o*, *o*1, encircling them to carry the hanks or skeins of yarn through the apparatus, and the invention

Fig. 1.

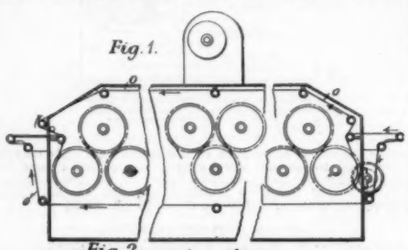
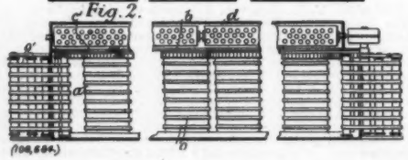


Fig. 2.



consists in so arranging hollow rollers *a*, and in mounting them upon supports or bearings *b* which will afford free access through comparatively large openings *c*1 leading to the interior parts thereof, from an adjoining chamber *d* in which air is heated and from which said air is forced or induced to flow through the comparatively large openings *c*1, to escape through the perforated peripheries of the rollers *a* and forward through suitable passages back to the same heating chamber, or to flow away as may be found advantageous. (*Accepted August* 29, 1917.)

109,763. R. Lambert, A. Barker, and William Eckroyd and Sons, Limited, Nelson, Lancashire. Loom-Shedding Mechanisms. (3 *Figs.*) May 22, 1917.—This invention relates to improvements in loom-shedding mechanism in which a front heald is connected to a back heald by flexible connections which pass round bowls below the healds, and in which the bowls are designed to give a greater motion to one heald than

Fig. 1.

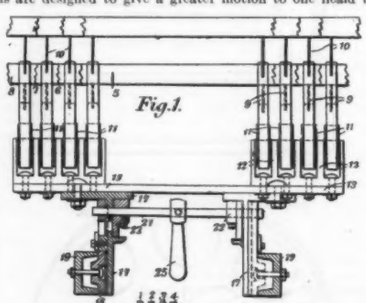
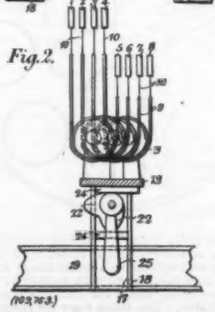


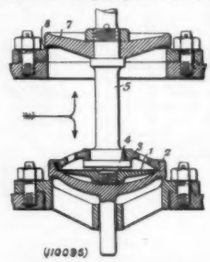
Fig. 2.



to the other, means being provided for raising and lowering the bowls to slacken and tighten the healds as required. According to this invention, the front healds 1, 2, 3, 4, are respectively connected to the back healds 5, 6, 7, 8, by flexible bands 9 and cords or wires 10 at the right and left-hand ends of the healds. Each band 9 passes under, and is attached to a bowl 11, which is rotably mounted in brackets 12 on the plate 13. Attached to the underside of the plate 13 there are brackets 17, which ar. fitted to slide vertically in guides 18 attached to the cross-rails 19. Rotatably mounted in the guides 18 there is a shaft 21, fitted with double-nosed cams 22, and a handle 25 by which the shaft can be turned in its bearings. The cams act between faces on the brackets 17, and the edges 24 of these faces are suitably rounded, while the cams 22 are made with flat noses, by which they are held in their placed positions. With the mechanism herein described, and when the plate 13 is in its lowest position the heald strings are held at a suitable working tension, and the upwards movement given to either set of healds by the tappet is transmitted by the flexible connections 9 to the other set of healds, which are thereby lowered. Both sets of healds are therefore compelled to move vertically in their own planes, and rubbing between the healds and the resulting disadvantages are avoided. The normal, or working, tension of the heald strings can be reduced for threading or other purposes by giving the handle 25 a quarter turn. This action through the cams 22, raises the plate 13 and the parts carried by it, and when this has been done the healds can easily be separated from the flexible connections and be easily connected thereto without interfering with the setting of the heald strings. (*Accepted October* 3, 1917.)

MISCELLANEOUS.

110,096. Cockburns, Limited, D. Cockburn and D. Macnicoll, Cardonald, near Glasgow. Valves. (2 *Figs.*) February 15, 1917.—This invention relates to double-beat valves, of the type fitted with a flexible diaphragm serving to effect the balancing of the valve and to compensate for unequal expansion. There is fitted to the beat which is held on its seat by the fluid pressure, a thin flexible metallic diaphragm 1, such diaphragm being imprisoned in a cell between the valve-element proper, *i.e.*, the member 2 having the seat-engaging face, and a covering member 3 secured to said member 2 and engageable with a collar 4 on the valve spindle 5, so as to roof the diaphragm cell, with clearance for admission of fluid to exercise downwardly-directed pressure on the diaphragm. The valve member 2 is



entirely closed on the side beyond the diaphragm 1, so that, in case of fractures of the latter, there is no passage through the valve member 2. The inner edge of the diaphragm 1 is in fixed relation to the valve spindle 5, the outer edge being nipped between the covering member 3 and the valve member 2. Between the two beats there is a clearance, the valve being balanced as long as the diaphragm 1 is intact. In the event, however, of fracture of the diaphragm 1, the fluid pressure acting on the valve member 2 will press such member against its seat, while the application of a slight external pressure will suffice to move the other beat 7 the distance representing the amount of clearance, *i.e.*, against its seat 8, so as to prevent escape of fluid. (*Accepted November* 17, 1917.)

QUEENSLAND MINING.—"The Mining Annual" is to hand from Sir Thomas Robinson, Agent-General for Queensland, and we extract from it the following general remarks:—"The value of last year's mineral output was 4,021,007*l.*, an increase, when compared with that of 1915, of 696,146*l.* This result was brought about by the improved values ruling for the industrial metals; or rather it should be said for the metals required for the manufacture of munitions of war. The gold yield has continued to decline in Queensland, as in the other States of the Commonwealth. In these days of high prices of the rare metals, the search for gold has lost much of its former attractiveness, while the experience of the past few years in that search has not been such as to offer any counteracting encouragement. While, however, this factor may have operated to some extent to the detriment of the gold output, inasmuch as without energetic prospecting there are not likely to be fresh discoveries, the outstanding cause of the decline is undoubtedly that the productiveness of the mines of our principal goldfields, which have in the past been the mainstay of those fields, is rapidly becoming exhausted. As to the other minerals, except in one or two unimportant centres and during some of the earlier months of the year, the year has been favourable both for the miner and the millowner; but one of the drawbacks that existed during 1915—the scarcity of suitable labour owing to enlistment—still operated, and despite the stimulating effect of high values and a ready market, the tonnage of copper produced was slightly less than in the preceding year, but the value very much greater. Of wolfram, too, there was a smaller yield, although an increase in its value; but of lead and silver there was an improvement both in quantities and values. Coal production, which had been advancing prior to the war, has fallen off a little during the past two years, partly as a result of the curtailed shipping of the principal port of the State owing to the war, and this year also on account of a cessation of work for some weeks during an industrial dispute which occurred in the month of November. For the current year the season, from a weather point of view, is decidedly promising, and the expected further expansion in the Cloncurry district, as the outcome of the starting of the Mount Cuthbert smelters, the enlargement of the Mount Elliott works, and the offering of further railway facilities in the extension to the Dobbin group of mines should lead to a greater output. The yield of the rarer metals should be further stimulated by the opening of the State battery at Bamford, as well as by the prospect of a continuance of high prices at least for some time to come."

THE INFLUENCE OF ASPECT RATIO ON THE CRITICAL ANGLE OF INCLINED SURFACES.

By C. H. POWELL, B.Sc., A.F.Ae.S.

IN the case of a flat plate inclined to a wind it is known that there is a certain angle of incidence at which the lift or cross-wind force is a maximum. We shall define this angle as the critical angle. It is intended to investigate what effect aspect ratio has upon the value of this critical angle. Reference is here made to some experiments made by M. Eiffel on planes of aspect ratio varying from $\frac{1}{8}$ to 9.* From these experiments the values of the critical angle for each plane has been deduced. These are plotted against aspect ratio in Fig. 1, which shows very clearly the following experimental fact: The critical angle increases as the aspect ratio diminishes according to a definite function.

In view of the natural unsteadiness of the air flow usually experienced at the critical angle it is remarkable that a smooth curve can be drawn through as many as six points out of the eight. Supplementary to this, investigations at the National Physical Laboratory on a long inclined wire,

Fig. 1.

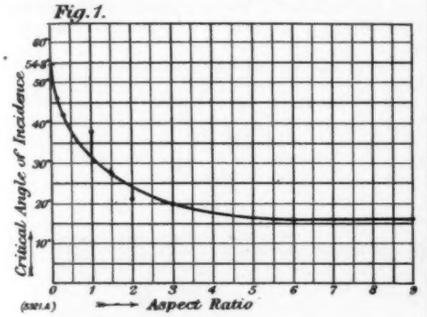
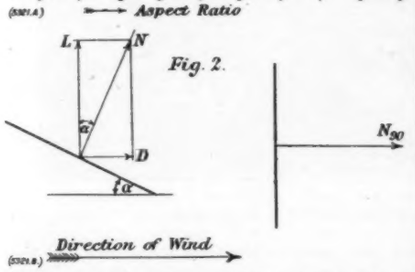


Fig. 2.



which approaches zero aspect ratio, show that the normal force is very nearly proportional to $\sin^2 a$, where a is the angle of incidence, Fig. 2, *i.e.*,

$$N = N_{90} \sin^2 a$$

roughly. This is quite in accordance with the foregoing, and it also appears that the nearer we approach to an infinitesimally small aspect ratio, or, the closer the inclined edges of a plane approach together and mutually affect each other, the more nearly will the normal force be proportional to $\sin^2 a$. It is interesting to note that Newton deduced this *sine* squared law for a purely hypothetical fluid.

We will now investigate the value of the critical angle for the case where the normal force is coincident with the resultant and varies as $\sin^2 a$.

Let L represent lift and N normal force, then

$$L = N \cos a = N_{90} \sin^2 a, \cos a.$$

For maximum value of L we have by differentiating and equating to zero :—

$$\frac{d\,L}{d\,a} = N_{90} [2 \sin a \cos^2 a - \sin^3 a] = 0.$$

Whence

$$\text{Sin } a = \sqrt{\frac{2}{3}} = .817$$

or

$$a = 54.8 \text{ deg.}$$

This angle is marked in Fig. 1 in the position for aspect ratio → zero.

It must be understood that variations in speed have also a considerable effect upon the critical angle. In the case of higher speeds than that of the experiments a curve would be obtained similar to, but probably slightly above that in Fig. 1, still, however, passing through 54.8 deg. for zero aspect ratio; while for lower speeds the criticals would occur at lower angles.

The practical importance of high critical angles from an aeroplane designer's point of view is, that a control surface, such as a rudder or elevator of high aspect ratio, will not give any further effect on the aeroplane after about 20 deg., whereas it is desirable for special manœuvres and "taxying" that the control surfaces should give a cross wind force increasing with angle throughout their range of movement, which at the present time on most machines is generally not greater than 40 deg.

The arrangement of having the controls as being part of the fin or tail, as the case may be, has the effect of increasing the critical angle because the aspect ratio of the combined surface is lower than that of either moveable surface alone. There is no particular advantage of having the directive organs and control surfaces of a very efficient type usually associated with high aspect ratio. The main point is that they should respond evenly to the joy stick and rudder bar movements.

* "La Resistance de l'Air et l'Aviation, 1911," pages 44–134.

THE AUSTRALIAN TRANS-CONTINENTAL RAILWAY FROM PORT AUGUSTA TO KALGOORLIE.

By E. A. BOX.

IN the sparing words of its engineer-in-chief: "The construction of the Port Augusta–Kalgoorlie Railway was a work of great magnitude and beset with unusual difficulties." The world has many transcontinental railroads. Some of them are longer than this first project of communications undertaken by the Federal Government of Australia. Many of them have involved greater engineering problems. The piercing of the Rockies; the traversing of the Andes; the penetration of the primeval forests of Central Africa alike have called for the daring and ingenuity of the surveyor and the engineer. But in none of them were there to be faced the same difficulties as those which had to be surmounted in throwing a single track from east to west across the heart of the Australian Continent. The line was part of the Federal compact under which Western Australia entered the Australian Commonwealth. It was to connect the Eastern railway system, ending at Port Augusta, in South Australia, with the Western system, whose "furthest east" was Kalgoorlie, flanking the famed Golden Mile of Boulder City. It was to be a line of high standard; the Federal Government set its face against any perpetuation of the tragic system of "broken" gauges by which the various State railways are divided into traffic-tight compartments. It decided to have neither the 3-ft. 6-in. narrow gauge of Western Australia nor the 5-ft. 3-in. widest gauge of Victoria, but to adhere to the 4 ft. 8½-in. world's standard, and to use its influence, and that of the Transcontinental, to convert the 3-ft. 6-in. trunks of Queensland and Western Australia, and the 5 ft. 3 in. of Victoria and South Australia, to the desired standard.

The Terrain.—Now the whole distance to be covered was 1,053 miles, not a great distance in a continent larger than the United States. The terrain varied considerably. Starting from Port Augusta the line crosses the head of Spencer's Gulf at Yorkeys Crossing. It then contours the rising ground to the westward, running through sand rises and gypsum banks, until a sparsely-timbered plateau gives occupied pastoral country with fresh water in wells for 200 miles. There are copper outcrops in plenty. Gold has been, and is being, successfully mined on the range at Tarcoola, 262 miles west of Port Augusta. From Tarcoola westward, the country becomes gently undulating, somewhat sandy, developing at about 380 miles west into a region of parallel sand ridges, as many as five to a mile, covered with "black oak," "mulga" and "mallee scrub," which, although there is no surface water, gives to the eye sweeping views of tossing greenness, and nullifies the careless term of "Desert" At 428 miles from Augusta the route debouches suddenly on to the famous "Nullarbor," an absolutely level and treeless plain—a plain as big as France, averaging 600 ft. above the sea-level. It is of limestone formation, covered with a good red soil, growing luxuriantly the salt-bush and blue-bush, most valuable food for stock. For 330 miles on the "Nullarbor" the line runs without a curve—the longest "straight" in the world. There is no surface water, but extensive boring is producing fresh water in large quantities. The Western Australian border is reached at about 592 miles west in latitude 30 deg. 45 min. south (see Fig. 1, page 678). At 850 miles from Augusta the plain ceases as suddenly as it began, and lightly timbered country accompanies the line right into Kalgoorlie. The greatest elevation reached on the route is 1,354 ft. This is at a point 107 miles from Kalgoorlie, which itself stands at a height of 1,240 ft. above sea-level.

On the whole route there are no steep ranges to be tunnelled. There are few defiles necessitating deviation. The grades are therefore simple. In the Eastern Division (*i.e.*, that portion of the line within South Australia) the ruling grade is 1 in 88, compensated for curvature, with a minimum curvature of 20 chains radius. The ruling grade in the Western Division (in Western Australia) is 1 in 80, compensated for curvature. This grade occurs only in the first 105 miles, after which there is no steeper gradient than 1 in 100. The minimum curve of 20 chains radius occurs only twice, and that within the town area of Kalgoorlie. At 400 miles west from Port Augusta the dreaded Sandhill Country, with its persistent swelling ridges, slightly transverse to the line of route, necessitated heavy earth works and considerable banking, when access from one valley to another had to be negotiated.

Organisation for Construction.—Let it be admitted, therefore, that the proposition was not an excessive one from the point of view of the surveyor. But let it also be remembered that in the "inside" of the Australian Continent "life" is spelt with more letters than in Europe. For life needs water, and of natural surface water there was none in the whole stretch of 1,050 miles. Given water on the route, and this description would have been written decades since: Water—and the soil, rich alike in minerals and fertility, would to-day be supporting a close population. But when construction commenced, at least 800 miles of the route was entirely uninhabited. Over the whole route there was no local population from which labour might be utilised, or food produced for man or beast. Organisation was therefore necessary of a kind quite unusual in ordinary railroad enterprise. It was less like an engineering job than the organisation of a campaign. The Commonwealth Government built it as a direct Government enterprise. What few contracts there were were subsidiary. Labour—practically all white—had to be brought hundreds, sometimes thousands of miles, and maintained permanently on the line. Construction had to embrace not only a highly-developed system of transportation of material, water, and other supplies; the Government had to provide stores and personal necessities for the workmen and their families; boarding houses, huts and food-ranches for the housing of the employees; postal, telegraph and banking facilities; medical and field hospital units; libraries and other necessities which, in other countries and under ordinary circumstances, are the care of private enterprise or other intermediary.

Water and Food Supply.—Water was the first and last thought of the engineers. Over the greater part of the route there are no watercourses of any size; an indication that the streams carrying off the rainfall are so little concentrated that opportunities of holding up volumes of water by the construction of dams was reduced to a minimum. The annual rainfall over the whole area does not average more than probably 7 in. There are occasionally intervals of *years* during which rainfalls are too scanty for collection. At Port Augusta an indifferent town supply existed at the outset. Another scheme had therefore to be added to the engineering programme. To the uninitiated, a more hopeless place in which to seek a water catchment never existed than the dry lands of Spencer Gulf. The surveyors and the well-borers of the overland line deserve well of their country. With

their camel teams and petrol engines they have punched holes in the most arid proposition to be found in Australia. The camel is bred in thousands in South Australia, and was used on the line for everything—haulage, riding, water carrying; he was, in short, "General Utility." For the Eastern Division, at 26 miles from Port Augusta, they laid toll to the one possible supply. An intake weir of 278,000 gallons capacity was constructed at Depôt Creek. Five catchment reservoirs of a total capacity of 30,000,000 gallons were constructed at intervals for 250 miles west from Port Augusta. Wirrappa (Fig. 2, Plate LXVI), with its massive concrete revetments, its asphalt-lined tanks of 5,000,000 gallons capacity, was one of the pioneers. In the Western Division the line possessed the advantage of the Mundaring pipe line supply at Kalgoorlie. The water had already made a journey of over 300 miles before it reached the Golden City. It had now to be carried by rail further east for the maintenance of the construction camps. The Western Division is off the artesian belt. In the quest for water, the boring parties went forward for hundreds of miles into the Nullarbor Plain. With the mirage and the Willy (*i.e.*, a fast-travelling spiral dust-whirl) for company, baked by the ever-present sun, chilled with the sweep of night winds across the waste, they wrestled with the living rock; dragged from its depths water which often reached the surface warm. The bores reached a maximum depth of 1,500 ft. The daily flow varied from 7,000 gallons to 70,000 gallons. The engineers thus provided adequate water supplies, not merely for construction, but permanently for line operations. But an immense amount of haulage for construction trains was inevitable. During one year of work, engine mileage amounted to 795,105 miles; and vehicle mileage to 8,748,000.

Next to water supply came the problem of food. For with over 2,000 employees scattered over sections 300 miles in length, the question of maintenance was serious. Added to which the men were of a race accustomed for generations to live well. They absorbed food generously. The Government opened provision and general stores for their needs. The stores had to be self-supporting. Bread and meat supplies were organised by the department on similar lines. The authorities did their utmost to prevent the sale of alcohol. In the Western Division particularly, huge "ranches" (*i.e.*, restaurants) were set up, run directly by Government, moving always with the gangs, and furnishing them with splendid food at cost prices.

New Construction Methods.—The construction work was commenced in July, 1912, by Mr. Henry Deane, Commonwealth Government consulting engineer. In April, 1914, Colonel Norris Bell was appointed engineer-in-chief. He drove the last dog-spike in October of this year. The line was built from both ends. It is of the standard 4-ft. 8½-in. gauge; 80-lb. rails were utilised. They are flat-bottomed, as is the custom in Australia, dog-spiked directly to the sleepers. The preliminary supplies were imported from America and England; the latter half from the local steel mills of New South Wales. The sleepers were, of course, obtained in Australia. Two and a-half million tons were utilised. Even engineers would have been immediately struck with their extreme length. For Australia "has timber to burn," and it was argued that the larger sleepers ensured a good road-bed, even before ballasting could be completed.

Again one has to note that the method of construction was not ordinary. The surveyors generally followed the bench-marks of the preliminary trial survey of 1908. In the areas of scrub and scattered timber, there had, of course, to be a certain amount of axework. In the main, however, the open plains and tablelands made for more expeditious methods. Mechanical methods were availed of to the utmost. On the heels of the surveyors came the petrol tractors, with disc ploughs which made light of stones, ripping up the light virgin soil of the overland. With scoops and horse and camel teams the road-bed was quickly formed. A "Castles" excavator was utilised for a time in the Eastern Division, completely rolling and forming the banks in one operation. Immediately afterwards appeared the construction train, headed by a track layer, a "notion" from America. The track layer was to become the "tank" of the overland route. It was rather a labour-aider than a labour-saver. Its swinging derricks operated by steam power from the locomotive, waved like the antennæ of a giant lobster over the prepared road-bed. From alternate flat-topped bogie wagons, the sleepers and rails were delivered into trough conveyors hung to each side of the construction train, mechanically-operated rollers passing them forward, to be gripped by the derricks (see Fig. 3, Plate LXVI); swung out in front to where a rushing gang of navvies slammed them down, to be hastily linked and dog-spiked into position on the earth cushion (see Fig. 4, Plate LXVI). It was arranged that the derricks on one side should be longer than the other. The sleepers were conveyed on the longer side, having to be delivered ahead of the rails. Every few minutes the train moved forward on the new-laid track; every few minutes the converging railheads in east and west moved closer together. Behind the track layers the line was pulled in, packed, and otherwise completed, by the fettling gangs and the *olla podrida* of a railhead camp. A temporary station was formed at each railhead, including a loop, and two "dead-ends."

Base Organisations.—A fair rate of progress of a mile a day was the object of the engineers, though it can hardly be said to have been attained. Yet every day the railheads moved forward inexorably in obedience to the capabilities of communication in the rear. Every twenty days there was something like an exodus. For the hutments and workshops of a thousand employees, the camp trains of the engineering and surveying staffs, the hospital cars of the medical section, recreation rooms, churches, cooks, camels, the miscellaneous paraphernalia of the railhead, moved also onwards to the new front. And in the Nullarbor, they said, a man might go to sleep on the morning of such a trek, wake on the site of the new encampment, and never know, from his surroundings, that the location of his camp had been moved.

With railhead and construction camps totally dependent upon the line for daily existence, both Eastern and Western Divisions had necessarily to be progressively complete and self-contained. What bridging work had to be done—for the most part the negotiating of dry, though sometimes wide, dongas—could never be allowed to hold up through communication. At such places, by means of slight deviations, the rails were led down into the bed of these depressions. The concrete piers and bridge girders were constructed later, and the line subsequently pulled into permanent position. Nor could conventional methods be followed even at the great base depôts at Port Augusta and Kalgoorlie, whence were distributed the hundreds of thousands of tons of rails and fishplates, and the millions of sleepers required for construction. For to Kalgoorlie the material was dragged over a line of 3-ft. 6-in. gauge, so that sidings of combined gauges had to be constructed to carry the alternative wagons; while at Port Augusta the material was received from ships' slings, after a long sea haulage up the narrowing waters of Spencer Gulf.

The Government took every possible step to safeguard the health of the men engaged on the line. The utmost care was taken to ensure good food. Hospital cars with proper dispensary and operating accommodation were provided in both sections. Medical attention and hospital accommodation were provided by the Government for all employees, who contributed a general sum of 6*d.* each per week. The total number of accidents on the whole work was well under 1,000, causing a total loss of life of about 20.

Rolling Stock and Equipment.—It was the aim of the Commonwealth Government to build a line capable of carrying traffic at high speeds. The line is of the best workmanship, and, so far as passenger accommodation is concerned, the engineers of the Commonwealth have been scouring the world for the latest ideas in travelling luxury. Huge day-and-night coaches, of a size undreamed of in England, saddled with its legacies of tunnels and bridges of a past railway age, will leave no device unexplored that will minister to the enjoyment of passengers. The Australians are inveterate travellers. They do not mind being in the train for a week, but they demand comfort. Ice in the hot weather, heating in the winter, and baths whenever possible. It is safe to say that they will make their great "through" expresses *trains de luxe*. Most of the construction rolling-stock, practically all of the locomotives and coaches for the new line, will have been built by Australians in Australia.

Fig. 1. The Borders of South and Western Australia.

Results achieved.—Such, briefly, is the history of a great undertaking. It has been accomplished at a cost of millions of national money, provided out of a consolidated revenue by the Australian taxpayer. It renders possible one of the longest railway runs in the world. From tropical Townsville, sheltered behind the Barrier Reef, the traveller may soon run by way of Brisbane, Sydney, Melbourne and Adelaide, to Perth, on the surf-beaten shores of the Indian Ocean—a run of 4,000 miles. He may do this in the running time of 150 hours. Every foot of the track is owned by the State. The line joins the Eastern system of 15,000 miles to its isolated daughter system of 3,000 miles in the west. It is a visible pledge of federation. It is the pioneer of many great similar projects which are aimed at the internal development of a continent. It provides for the military defence of the country on interior lines. The voyage from west to east of the Continent has been halved in point of time. And the tenacity of Australian engineers has tamed the wilderness. Out in the former "unknown" settlements have already sprung up along the line. The optimism of their population is expressed in names like that of "Golden Ridge" (Fig. 5, Plate LXVI), but it is an optimism that has subdued deserts, and is making the Australian Nation.

THE ARRANGEMENT OF MACHINE SHOPS.—No. XXII.

By JOSEPH HORNER.

THE example of shop arrangements illustrated in this article is that of a works occupied wholly in the production of one speciality—that of gear wheels. The firm of Messrs. David Brown and Sons (Hudd.), Limited, of Park Gate Works, Lockwood, Huddersfield, commenced business a generation ago with the making of foundry pattern gears for the trade. From that beginning the present works has grown. It is occupied now with the cutting of all classes of wheels, including the double-helical type—the last addition—one which is regarded with increasing appreciation. The firm makes a speciality of totally enclosed reducing gears, both of the worm and the double-helical kind, and produces a large output of high-speed turbine gearing for Admiralty and other requirements. Owing to the specialised nature of the manufacture, many of the gear cutting machines have had to be designed and built by Messrs. Brown, who also make a considerable number of machines for sale.

The lay-out of the works is seen in the block plan, Fig. 216. The photographs reproduced on Plates LXVII to LXIX, published with this issue, are views in some of the shops. The inscriptions on the plan show at a glance the locations of the various departments. It will be observed that although the ground area is not wholly rectangular, as is generally desirable, the bays are all strictly arranged in parallel. Also that the firm has made itself entirely independent of outside help, in possessing its own pattern shop, foundry, smithy, and hardening shop as feeders to the numerous machine shops. Again, the departments are minutely subdivided both in reference to the class of gear being produced, and also according to the kinds of tools that are used in the preliminary work of the preparation of blanks, of gear boxes, shafts, and so on. The tool room and the tool stores are located between the heavy machine and erecting shops on one side of the private road which divides the buildings into two groups, and the specialised departments that occupy the block on the other side of the road. The buildings are of the one ground floor design. Only the offices, and two balconies devoted to light fitting occupy upper floors.

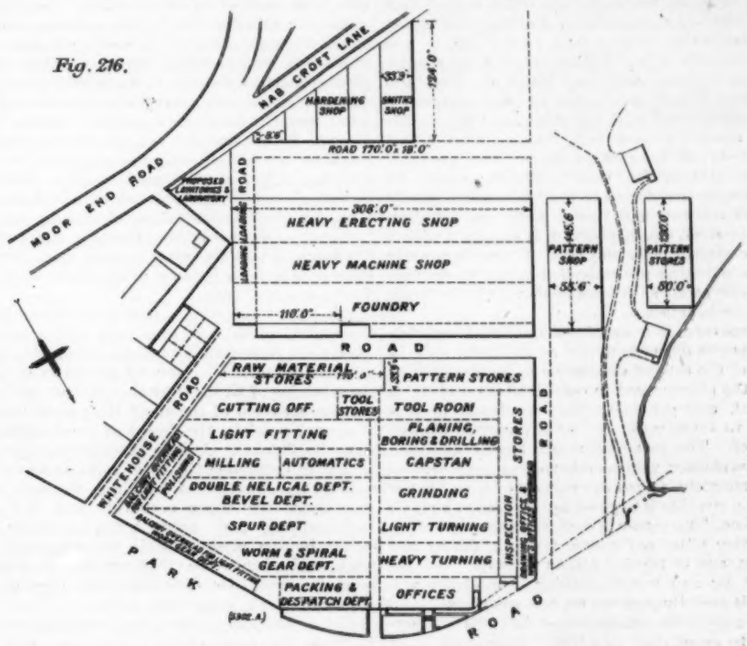
The photographs reveal the admirable arrangements of the long parallel bays, which range from about 120 ft. to 310 ft. in length. Some shops are seen provided with floor tracks. Overhead electric travelling cranes of from 10 tons to 25 tons power serve the bays. The lighting is done by double continuous skylights in ridge roofs the artificial illumination is with arc lamps. The works are electrically driven throughout, the power being obtained from the Huddersfield Corporation. In the case of large machines there is a separate motor drive for each machine, but the smaller tools are driven in groups from line shafting. Each group is driven with a 40 h.p. motor, running at 1,440 r.p.m., which is connected to the line shafting, making 200 r.p.m. by means of a standard totally enclosed single reduction double helical gear having a ratio of 7.2 to 1, of which reduction gears the firm makes a speciality.

Fig. 217, Plate LXVII, is a view in the department where the latest addition to the firm's plant may be seen, namely, the double helical gear generating shop. The machines used are of a special type, of which Messrs. Brown hold the sole patent rights. In these machines the teeth of the gears are generated by means of rack shaped cutters which reciprocate at an angle corresponding with the helix angle of the tooth. There is one cutter for the right-hand portion of the gear, and another for the left hand, and the two move towards the centre of the gear alternately, and are so arranged that the stroke of each one terminates exactly at the apex of the tooth. At the same time that the tools are reciprocating in their slides, they are slowly fed in a direction tangentially to the pitch line of the wheel, and the latter is made to rotate in such a way that the cutter and the gear blank have the same relative movements as those of a rack and its gear. A battery of these machines occupies one side of the bay in Fig. 217. On the other side, straight-cut bevel gears are generated on special machines, amongst which are included the Gleason, and the Bilgram types, and some Gleason form machines.

Fig. 218, on Plate LXVII, is taken in the bay where worm and spiral gears are cut by the hobbing process. The heavy turning bay is seen beyond, and is shown separately by the view, Fig. 219, on the same plate. The lathes on the left are 42 in. chucking lathes designed and built by Messrs. Brown. On the right are a number of vertical turning and boring mills up to 12 ft. 6 in. swing.

Fig. 220, on Plate LXVII, illustrates the spur gear cutting department which is equipped with all the latest types of gear-cutting machinery, including the Gould & Eberhardt, the Sunderland generating machines, the Brown and Sharpe, and a number of Fellows gear generators, one of which is seen in the foreground to the left. Fig. 221, on Plate LXVIII, is the worm-milling shop, a department in which the machines used are of the firm's own patented design and manufacture.

Fig. 216.



The succeeding views show photographic illustrations of the interiors of other shops, for the several locations of which the plan view, Fig. 216, is to be consulted. The general grinding department is seen in Fig. 222, on Plate LXVIII. Here the cylindrical machines predominate; but there is a vertical surface machine on the left. The products being of small dimensions, numerous stands, and wooden trays are disposed to receive them. The worm-grinding department, Fig. 223, Plate LXVIII, is equipped wholly with special machines of the firm's design, having wheel heads which are adjustable to angles to suit the various gears. After the threads have been milled they are hardened, and then brought here to be ground. Fig. 224, Plate LXVIII, shows the polishing department, provided with polishing heads, wheels and buffs, and a dust-exhausting series of pipes.

Fig. 225, Plate LXIX, is the turning bay having four rows of lathes of between-centres design, these being kept separately from the chucking lathes and the vertical boring and turning mills that are illustrated in the photograph, Fig. 219. They are engaged chiefly in turning worm blanks, including those—a very large proportion now—which are forged solidly with their shafts. One side of the tool room is visible on the left.

A testimony to the immense present employment of the once despised worm gears is afforded by Fig. 226, Plate LXIX, this view showing the bay in which worm wheels are milled and tested. The machines used are of the firm's own design and manufacture, and are strictly "single-purpose" machines—to use a phrase now current.

Besides the shops referred to above there are other important departments which we are unable to illustrate, but which demand notice. One of these is the planing and drilling bay, crowded with machine tools, and served with an overhead travelling crane. The planers occupy one side of the shop, while on the other side are the drilling machines, which include the pillar, and the radial designs. A very miscellaneous quantity of work is done here, largely consisting of gear-box elements, and portions of the machine tools which the firm manufactures for use in their own shops, and for other establishments that are engaged in gear cutting.

Another shop is occupied with the automatics, which are mostly chucking machines for dealing with wheel blanks, and of heavy designs. The piles of blanks testify to the rapidity of output. It represents a class of work that only a few years since was regarded as a legitimate task for the common turning lathe, or for the vertical turning and boring mill. The sets of tools carried in the automatics leave the performances of those older methods far behind.

Other shops not illustrated are the worm gear testing department, the capstan and turret lathe bay, a bay with a battery of automatics for the machining of gear blanks in quantities, and for handling small pieces of a repetitive character. There are also planing, boring and drilling shops, a turning shop, and a bay devoted to cylindrical grinding which is capable of handling pieces up to 36 in. diam. by 16. ft. long.

A particularly interesting department is that which is devoted to the generating of automobile worm wheels, and to that of worm grinding. The machines here have been designed and manufactured by Messrs. Brown, and are covered by a number of patents. The firm has a very large output of this class of gear. It is of interest to note that they have supplied duplicate plants to that in use at their own works for the United States, France and Italy. The work is now moved from one department to another by means of electric battery trucks. These are in general use throughout the shops, having superseded the floor tracks previously in existence.

The tool room is a department of the first importance in a works where economical production is desired. It is a small shop enshrined within the big one which it serves, but its value is not to be measured by its extent. It is much more than its name would seem to imply, that of a department devoted to making and keeping in repair the tools

used in the shop. It is the eye of the machine shop, the centre where all the details of its work are schemed. It is, in its more advanced examples the place of central control in which the operations of all the machine tools are rigidly determined. It is also the room where the jigs and fixtures are designed as often as a new piece of work is undertaken, and where they are constructed to suit both the work and the machines on which they are to be used, and in which they are stored. The tool room and the system of the shop which it serves and controls are so vitally associated that one cannot be understood apart from the other.

The growth of this system of centralisation is one of the inevitable and necessary issues of the interchangeable methods which have now become deeply rooted in engineering manufacture. Apart from this system, it would be impossible to maintain the accuracy of the tools, gauges, and fixtures on which in the last place the success of the system depends. It could not be realised if every man should be permitted to do that which seemed right in his own eyes,—correcting, guessing, and trying, and unavoidably wasting very much time as was usual in the old days. Neither would it be possible to avoid misplacements and losses of tools and appliances in large shops. Out of these movements and needs the tool room has arisen, and grown. No longer always a room only, but as some recent illustrations of locomotive shops have revealed, it is an area of fair size, numbering within its borders some few dozens of machines, and a goodly range of benches, and though these are not illustrated in small scaled plans, it is equipped with a large number of racks and bins. The arrangements and methods that are embodied herein we propose to consider as far as is practicable within the limits of the present article.

The tool room is a machine shop in miniature, but its equipment differs from that of the main shop in respect of the smaller dimensions of its machines, of and in the employment in considerable numbers of universal, and general-purpose machines, in preference to those which are of a highly-specialised character. The tool makers are mostly all-round skilled mechanics, who operate the various machines indiscriminately, unless the volume of work that is done on a machine is large enough to occupy a man's whole time. This occurs in drill- and cutter-grinding, in grinding lathe and planer tools, in fluting and relieving, and in turning blanks for tools. In the work of jig and fixture making a mechanic will carry his task through on several machines.

It is only in the smaller shops that men are permitted to grind their own tools. Consequently, as often as these become dulled or damaged by wear, they have to be returned to the tool room, and are handed out again when corrected, each movement in and out being recorded by means of a suitable check. To the old-time hand this system would have appeared to savour of red tape, when he might himself carry his tool to the grindstones, and touch it up in less time than might be consumed in checking it in and out of the tool room. But the best results are now undoubtedly secured by the employment of grinding machines in which fixed angles and dimensions are embodied by means of mechanical control determined exactly for different forms of tools, and for the various kinds of materials on which they operate. The chances of improper hand-grinding are eliminated, and the aggregate saving in time, and the general increase in efficiency outweigh any loss that is entailed by the checking of tools.

Behind the particular equipment and the system which is crystallised in the tool room, and of equal, if not of greater value than these, is the possession of an expert knowledge of the nature and extent of the operations which each machine in the shops is capable of performing. Also, an acquired experience of the relative utilities of tools of different kinds, which, though diverse in character, produce identical results by dissimilar methods, and with notable differences in cost. This kind of knowledge must be precise, accurate, extensive, and the scheme of production that is based on it and embodied in the tools and fixture has to be carried through rigidly and minutely by the men in the shops.

The equipment of tool rooms found in different shops does not vary greatly, except in regard to the numbers of the machines installed therein. These are all of light or of medium build, and generally include the following: One or more lathes, a shaper, a milling-machine (of the vertical type preferably if only one is laid down), a Universal gear-cutting machine, a Universal grinder, a cutter grinder, a hack saw, a drilling machine or two, a light slotting machine, and a hardening furnace, together with standard measuring instruments—rules, micrometers, vernier instruments, gauges for the shop use, and for reference, and a measuring machine. There are also vice-benches, drawers, a marking-off table, tool racks, cabinets, bins, and, frequently, a blue print store is included.

The tool room equipment of machine tools it may be observed is not like that which is laid down in the shops for dealing with highly-repetitive products. It resembles that of the small general shops in the fact of the employment of Universal machines, and in the absence of turret lathes, and specialised, and single-purpose tools that are suitable for dealing with large numbers of similar pieces. The majority of the jobs that are done in the tool room are produced in single sets, or in small numbers only, where each article stands alone, or nearly so, the parts of which need not interchange with other parts; the standard screws, pins, bushes, studs, and some other special fittings used on jigs, fixtures, turret sets-up, &c., excepted. Another fact is that the machines are not all being run regularly, but some may lay idly for considerable spells. Therefore, though no heavy machines are installed, the case is one for which individual electric driving should be favoured, or short lengths of shafting, motor-driven. Shafting and belts are better avoided, since abundant light is necessary, because most of the work done is of a fine character.

The chief man, who is primarily responsible for the control of the tool room and for its initiative work must possess the knowledge of a highly skilled practical mechanic. Upon his shoulders is thrown the scheming of all the work that is controlled there, the due selection of the small tools to be used out of several possible, the design of the templets, the jigs, the fixtures. And in association with these he has to determine the most suitable methods of tooling, the selection of machines, the best speeds and feeds, the times occupied, and the costs. Handicapping may occur when machines that would be the most suitable are congested with work, and when some that are not so desirable must be used. Or difficulty may arise in consequence of all component parts not being completed in the same times, and rearrangements of methods may be necessary. Here then is a most extensive field fraught with many possibilities of alternative methods, of other ways of achieving like ultimate results.

The initiative for all these broad schemes and minute details is removed, just as is that of tool grinding from the men who have charge of the machines in the shops. All their operations are predetermined in the tool room. These involve the selection of one method of tooling in preference to another, or others, as shaping, planing, or milling, of cutting, or grinding; of turning, boring, reaming, or grinding; or of an apportioning of the work between two or more methods. And the limits of gauging are determined also, and the exact gauges for those limits are provided. In its highest developments the tool room control settles the methods of gripping the work in chucks, or in fixtures, instead of directly on the tables of the machines, and often now the exact sequence and the times occupied in the several movements entailed in the latest route, or motion systems.

To ensure success in a system so rigid, and to avoid disastrous miscalculations, an expert knowledge of the nature and the extent of the operations which every individual machine is capable of performing, and of the possibilities that pertain to the judicious employment of jigs and fixtures must have been acquired in a practical way in the shops. And this kind of acquisition tends to become more difficult, because methods of tooling and the outputs of machines are in a state of rapid and constant flux. The only way to success is to abandon all preconceived notions that have accumulated and hardened by experience of old-time methods, and to approach the nascent problems of the present with an open mind. No method should be accepted as being beyond question, merely because it has been established by long precedent. That assumption would prove fatal to all growth, advance and efficiency. The expert has to deal, not with the machines and the practice of 10 years, or even say three years ago, but with the machines now in evolution, and the methods that are suited to them. These, in the most fully equipped shops have wrought, or are working tremendous changes in practice.

In a small machine shop, no difficulty is found in charging the memory with the capabilities possessed by each individual tool, its power, its range of capacities, its speeds, feeds, and output. But in a large works this is not possible. Yet it is essential that these data should be known in the tool room if work is to be arranged in its correct and complete sequence of operations. For this purpose a record must be kept in the tool room of the capabilities of every machine in the shop, on which the dimensions, centres, sizes, of work tables; clearances, travels, and traverses, speeds, and feeds are all stated. These records may take the form of small blue prints kept for reference in albums, or on boards, duplicates of which may be attached to the corresponding machines in the shop. It is essential to the success of such a scheme that the times of production on which estimates are based in the tool room shall be rigidly adhered to, and not be varied materially except of necessity, and then only by arrangement with the tool room. Hence a loyal co-operation between shop and tool room is essential. Tool room experts are not infallible, machines have their idiosyncrasies, hence the schemes of production may need to be modified after friendly consultation between the tool room and the foremen of departments. If a machine does not produce the quantity on the basis for which its output has been estimated, the total output will lag. The knowledge of the relative utilities possessed by different tools which produce identical results by means of dissimilar methods is a detail which is of much importance in the arrangement of operations by alternative methods. For when a series of related operations has been determined and got into swing, the entrance of a new machine or machines with other methods may reduce the times of operations by very considerable amounts, provided usually the volume of repetitive work is sufficient to keep machines in constant service. This is the reason why it has sometimes been deemed consistent with the truest economy to throw out machines that are in excellent working order, and replace them with later designs, the output from which justifies the capital outlay involved.

The movement which has brought the importance of the tool room into prominence after that of tool making, grinding, and repairs is the ever increasing employment of jigs and fixtures. These inevitably crystallise the methods of the shop in which they are used, into uniform patterns. Templating which was the crude prototype of these aids, and that is still employed for pieces of large dimensions leaves the actual methods of tooling, and also of holding, usually undecided and open to the choice of the workman. Not so does the jig, or the fixture. The first-named controls the tool only, the second locates and secures the work and frequently the tool receives guidance. Each is designed with reference to its employment in some one machine, or type of machine, drilling, or milling, &c. The more intricate and the more expensive these are, the more necessary is it to avoid having to redesign them in order to secure a closer margin of economy.

The tool room embraces the tool stores. Within it the small tools are arranged in bins, drawers, racks, suitably labelled, and recorded on cards to be checked in and out. In a large shop this entails a good deal of clerical labour. But it enables the location of any tool to be ascertained within a minute or two. This is mere routine work. Much more is entailed in the conduct of the tool stores. In firms where work is highly specialised, a system is adopted of sending out all the tools, jigs, and fixtures that are required for the performance of a series of operations carried through by one man

or set of men, under one indent enclosed in a portable chest or cabinet. This practice is in harmony with the system of control which is exercised by the tool designers and route-men in determining exactly how a given article shall be produced, the sequence of the operations, and the nature and number of the tools involved.

These boxes—"tote boxes"—to use an Americanism, are stored on shelves as complete units. But when they contain, as they commonly do, some tools which are not made specially for the piece to be operated on, as standard drills, reamers, taps, &c., these need not remain idly in the box when not in service, but may be returned to their own proper racks or drawers, to be handed out for other duties. This increases clerical work, but it economises the stock of costly tools. It is not always convenient to include a large equipment in a box, but the essential system can be efficiently carried through by making out a list of the tools and appliances, and handing these out to the operator under his check number.

Alternative to this complete system, but often leading up to it is a sort of half-way practice. In this, the tools, jigs, and fixtures are stored in the tool room. The general stores, in which the elements that are required for fitting and assembling the screws, bolts, washers, pins, &c., are kept, are located elsewhere. The bolts, stops, packings, angle plates, and so on, that are used on machine tables remain permanently on stands adjacent to the machines which they serve. Stocks of small tools, fine tools, and gears, mandrels, and spanners which are regularly used on a machine are stored in cupboards or in racks attached to it, or built into it, illustrations of which have been already given. These are only returned to the tool room when, in consequence of wear and damage they need correction. This method has the advantage of saving much walking to and fro, and of clerical work, though it entails the carrying a large stock of tools and appliances, and reduplication of very many. In these matters the requirements and conditions which characterise each shop must be assessed separately.

Among the appliances with which the use of the tools is associated are the tables provided for the viewers or inspectors. Some of these designs bear some resemblance to an ordinary chest of drawers, but the top is a planed-iron table on which surface gauges, squares, and packing blocks have a true basis for their operations. The drawers occupy the body of the structure, and provide a tool cabinet in which the gauges and other instruments of measurement are protected. Some marking-off tables are constructed with heavy timber framings, and covered with planed iron tops. The timber frames permit the fitting of drawers to hold the small tools.

The best selection of the methods of storage to be adopted in the tool room is a problem which is not so simple of solution as it was formerly. One reason for this is the immense increase in the numbers of the tools and appliances, the other is the tightening of centralisation, which is almost an inevitable result of the first.

There is no possibility of avoiding enormous increases in the numbers of small tools and appliances, or of evading the system of centralised control with which their employment has become interwoven, if a works is to occupy a position of success. The intensive production of munitions has done more to favour these movements than a dozen years of plodding shop developments could have accomplished. And with these expansions the question of providing the most suitable methods of storage becomes more acute. The tendency is to store more in the tool room, and less around the machines, with the manifest advantage that the whereabouts of any article can be located at once. It is either in the tool stores, or it is out in the shop, and if in the shop, the number of the man in whose charge it is is ascertained by reference to a check or a card. This includes the checking of blue prints. The system of checking in and out varies rather widely in matters of detail, but at the basis of all is the fact that to each man a number is allocated, and only through that number may he receive a tool out, and return it into the room.

When a shop is of very large extent, the central tool room may be the feeder of satellite tool stores, with a view to avoid loss of time in lengthy journeys. This is desirable in those shops which are sharply subdivided into departments, as the gear-cutting section, the milling area, the planer shop, the grindery, and so on. And particularly is it so, when the tools, and the fixtures are of considerable size and weight to be handled.

Fixtures and jigs again are frequently made for service on one machine only, or on a few similar or related machines arranged in groups. In such cases it seems desirable that they should be stored in a room adjacent to the machines on which they are regularly used.

Small tools are stored in open racks, or in cabinets fitted with drawers. These are made in wood, or in metal, or the two materials are combined. Using metal, there is slightly more risk run of damaging the edges of cutting tools, with wood. when saturated with oil, the chances of fire are increased, and wood is not so readily kept free from oil and dirt as metal is.

The racks and cabinets are designed to carry certain tools or groups of tools, and no others, so that they assume a great variety of forms. In all cases, it is desirable to restrict racks and bins within a limit of height, so that the upper shelves can be reached without the help of a ladder. If floor space is limited, and height is unavoidable, then the lower shelves should be used for the articles which are in more frequent request, and the upper ones for those that are less often called for.

Racks and bins are used alternatively to cabinet drawers, and to revolving stands for storing cutting tools. Contact between the edges has to be avoided. Thus if drills, reamers, milling cutters are laid side by side horizontally, or on a slight angle, contact is prevented by the interposition of separating strips of wood. Drills, reamers, and taps are often stored vertically with their cutting edges upwards, in holes bored in blocks of wood.

A very convenient method of dealing with hollow reamers, gear cutters, and milling cutters having central holes is to slip the holes over wooden plugs disposed on leaves around a central stand. The plugs stand out from the leaves or wings at a slight upward angle from the horizontal to prevent risk of the cutters slipping off accidentally. Any tools can be brought into view by revolving the leaves around the pillar and base. Plugs are inserted on both sides of the leaves. Instead of hinged wings, some stands have polygonal faces, each face being provided with wooden pegs, and the polygon is rotated round a vertical axis. This does not furnish so much area as the first-named affords. Another form, modified from this is that in which sliding planes run on rollers guided by tracks above and below, carrying pegs on each face. A series of these planes is disposed at suitable distances apart to permit of the pegs and tools clearing those opposite when run in. These methods are only available for cutters that have central holes to fit on arbors. Those with shanks are stored on open shells, or in closed cabinet drawers.

The systematisation of storage in the tool room has been fostered much by the manufacturers of bins, shelves, and cabinets for all the purposes for which storage is needed. In these as in other matters the specialists can turn out articles more adaptable, neater, more accurate than firms can make for their own requirements, and usually at less cost. Racks and bins are made in unit lengths which can be extended by the addition of fresh units when the capacity of the original element is outgrown. A single unit is subdivided into separate square sections, into which smaller units can be fitted for the separate storage of different kinds of tools. And these may be either trays, or shelves, or boxes, or drawers.

Tool room cabinets are built up in tiers, each tier including a large number of drawers of graded depths. The ends of the drawers have grooves cut in them for separating strips, the positions of which can be varied as required. A brass label holder is attached to each drawer. Each tier is secured with a hinged flap provided with a lock.

In a cabinet for limit gauges the disposition of the gauges is seen at a glance. The size and limit of the gauge is marked on its tray. A distinctive colour, painted in a slot indicates that the gauge occupied its place. The insertion of a workman's tool check in the slot shows that the gauge is in the possession of that workman. The opposite end of the tray being painted another colour, and the tray being reversed, indicates that it is one to which no gauge has been allotted.

At the present time, when small parts are standardised for repetitive production it is necessary to keep a record of these in the drawing office, and in the tool room, and the jig and fixture departments, for the purpose of ready reference to all concerned. This is a matter of vastly greater importance now than it was formerly, because so much more is involved than in the periods when interchangeability was not so general. For the production of a single small piece, a large number of jigs or of fixtures may have to be made, and stored and for use on several machine tools. Frequently, therefore, instead of referring to drawings, a single standard piece of each kind is stored in a place convenient for inspection, each having a tag with its descriptive number and symbol attached. Cabinets are made for the storage of these elements, having hinged leaves, on each side of which hooks and slips are fastened for the attachment of the parts. In this way small gear wheels, bushes, levers, screws, handles, springs, &c., can be conveniently hung up in full view.

GERMAN WAR PROFITS.—The profits of the Rombacher Hütte for the year 1916–17 amount to 8,886,824 marks, against 5,135,489 marks for the previous year, writings off amounting to 5,989,586 marks, or 2,000,000 marks more than for 1915-16, and 721,276 marks as war aid to employees having been provided for. Whilst the profits fall a trifle short of the figures for 1912–13, the dividend for last year amounts to 12½ per cent. against 10 per cent. for the year referred to, and 8.5 and 5 for the years 1915–16, 1914–15 and 1913–14. The Hartikorn Mining Company and Chemical Works have earned net profits for last year amounting to 2,118,627 marks against 1,535,899 marks for the previous year, the dividend being fixed at 14 per cent. against 10 per cent. for 1915–16. Some shareholders in the Sachsische Cast Steel Works, Döhlen, were dissatisfied with the declared dividend of 30 per cent., considering themselves entitled to 43½ per cent., in view of the Board obtaining 802,000 marks as their share of the profit; they were, however, entirely outvoted, and the chairman flatly declined to give the slightest information on the point. The Upper Silesian Zinc Works have last year earned 1,045,766 marks net profits against 367,375 marks for the previous year, and pay 10 per cent. dividend against 7 per cent., 450,000 marks being reserved for reconstruction after the war, nothing having been put aside for this purpose last year. The Westphalian Iron and Iron Works at Werne pay 10 per cent. for the last year. The current year was so far satisfactory, but there was shortage of fuel which caused considerable trouble.

CRYSTAL GROWTH AND SOLUBILITY.—The causes underlying the regularity of the growth of crystal and their re-solubility, in other words, the determining factors in the equilibrium between a crystal and its own solution, are by no means understood. It is largely assumed that different crystal faces have different solubilities (P. Curie), and that there can only be equilibrium between the crystal and its solution, when the form of the crystal is such that the surface energy is a minimum (G. Wulff). A Ritzel has combined the two views, both of which, however, seem to lack sufficient experimental and theoretical basis. Rosicky, of Prague, showed in 1914 that the different crystal faces of rock salt, which has always been considered as typical and representative of the regular system of crystallography, behave differently with respect to certain etching agents (especially aqueous solutions of sodium chloride itself), but not with respect to other agents (acids), which would be a very peculiar case of asymmetry. On the other hand, J. J. P. Valeton (K. Sulhsische, Gesellschaft der Wissenschaften, 1915) could not, in very careful experiments with potassium, alum and other salts, find any traces of different solubilities in different directions: he kept his solutions constant within ± 0.002 deg. C. and constant as to concentration for days, experimenting with crystals ranging in size from 2 mm. up to 20 mm. Arguing thermodynamically after Gibbs he concludes that, in microscopic crystals, the surface energy has a measureable influence on the solubility, and that such crystals can only be in equilibrium with their solutions if their form correspond to the minimum of surface energy. That influence would hardly be appreciable in microscopic crystals, however, and it would indeed be difficult to understand how monoclinic and triclinic crystals, which are certainly not symmetrical, could be in equilibrium with their solutions if they had different solubilities in different axial directions. Yet it is generally believed that the big crystals of metals grow at the expense of the small ones, and the crowding of atoms in different planes, as disclosed by Röntgen-ray analysis, may help to clear up the difficulties.

IRON ORE LOADING PLANT AT BILBAO.

CONSTRUCTED BY MESSRS. FRASER AND CHALMERS, LIMITED, ENGINEERS, ERITH.

Fig. 1.

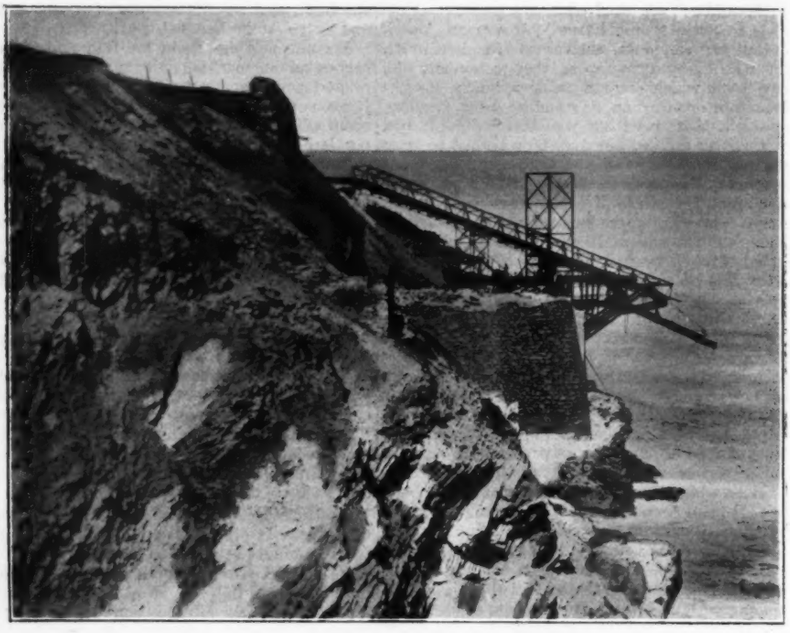


Fig. 2.

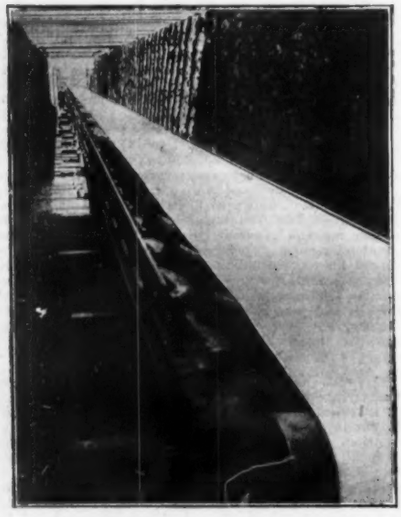


Fig. 3.

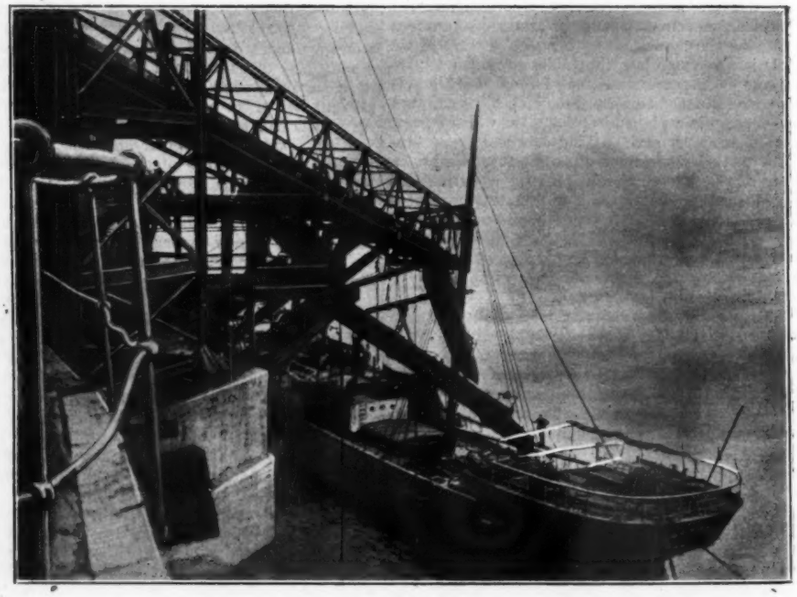


Fig. 4.

IRON ORE LOADING PLANT AT BILBAO.

By George Frederick Zimmer, A.M.I.C.E.

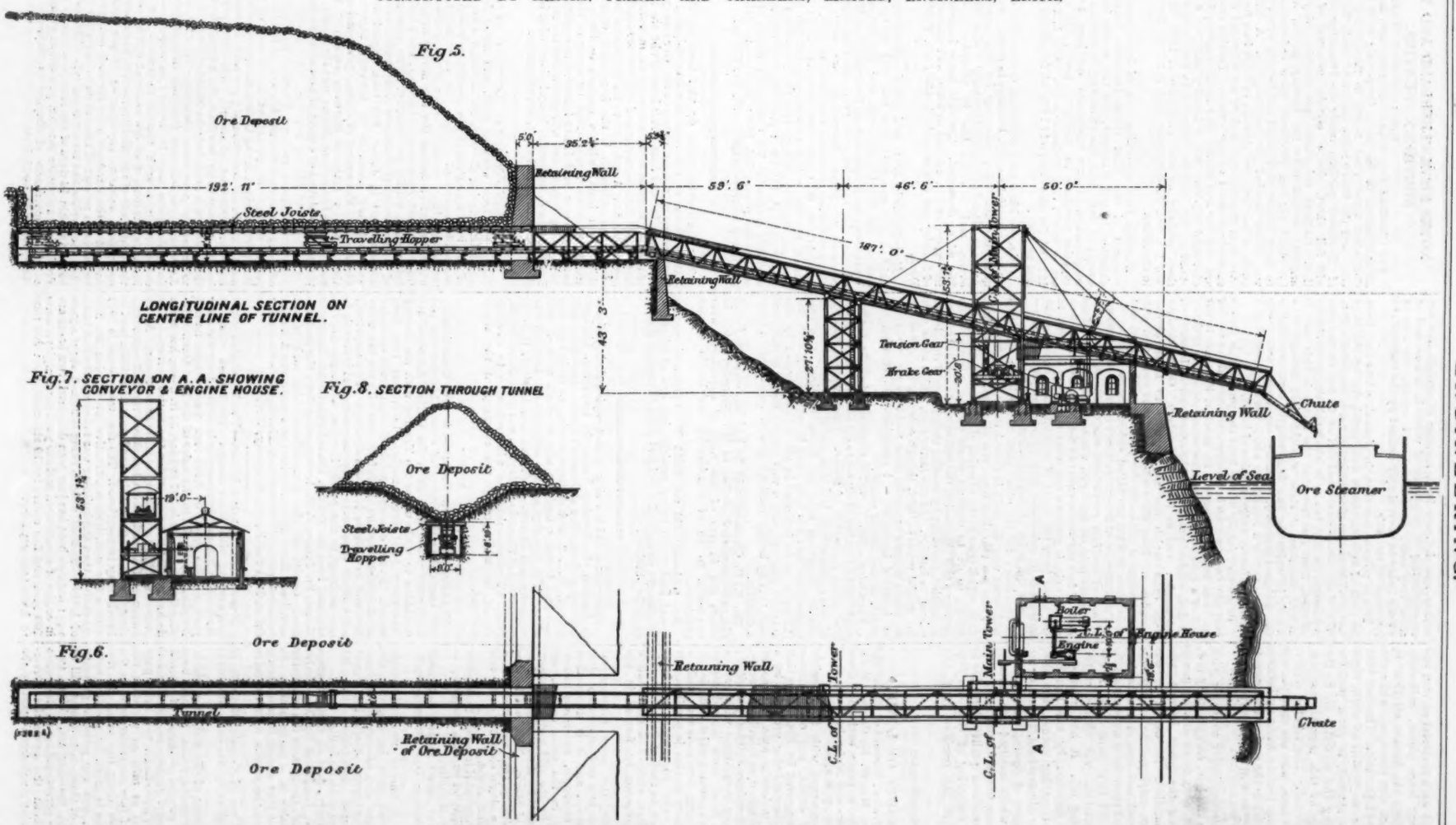
The loading plant for iron ore at Bilbao, of which we give general views in Figs. 1 to 4 on the present page, has some quite unusual features, as will be seen by a glance at the drawings. The installation was designed and erected by Messrs. Fraser and Chalmers, Limited, of Erith and London, for José McLennan, Bilbao, Spain. Although the plant is not of very recent date—it being the first installation of a high-capacity loading plant erected—its description has been withheld until it had stood the test of time, and it has now proved to be an unqualified success.

As will be seen from the general views already referred to, and by the drawings reproduced in Figs. 5 to 8 on the opposite page, the plant consists essentially of a band conveyor with a total length of 380 ft. from centre to centre, and a width of 36 in. This band runs partly in a horizontal direction under a large ore pocket, and partly at a downward gradient, deflecting some 13 deg. from the horizontal and terminating well over the water into a delivery shoot. The high-level terrene close to the deep water where the vessels can be loaded alongside, has been exploited in the best possible manner in order to harness gravity as motive power, thus permitting the surplus energy developed by the descending load on the inclined path of the conveyor to overcome the frictional resistance of the horizontal portion, so that the whole length of the band conveyor, some 380 ft., handling about 1,000 tons of ore per hour, can be manipulated wholly by gravity, from the ore dump to the hold of the vessel.

It is, however, obvious that the upper horizontal portion of the conveyor, which is of a fairly long stretch, and holding as it does a considerable weight or ore, will offer too great a resistance to be started automatically by the inclined portion when the latter is unloaded; it is therefore necessary to provide some motive power to start the plant. For this purpose a small steam engine has been installed, which is shown in the drawings, and which drives by belt and countershaft on to the driving drum of the conveyor. This engine is only run to start the plant up to full speed, after which it is declutched, and the conveyor runs by gravity. If unchecked, the band attains a very high speed of working, and it has been observed to have a speed of up to 1,000 ft. per minute. The conveyor is controlled by a man operating a powerful brake on the flywheel on the conveyor, which does not permit of a band speed of more than 400 ft. per minute. This brake may be seen from the illustration, the man attending to it does so by a hand wheel in the engine-house, and he can run it at quite a

IRON ORE LOADING PLANT AT BILBAO.

CONSTRUCTED BY MESSRS. FRASER AND CHALMERS, LIMITED, ENGINEERS, ERITH.



variety of speeds. Close to the main driving wheel of the conveyor is a weighted take-up arrangement to automatically keep the belt taut. The horizontal portion of the band is 193 ft. long, while the inclined portion is 187 ft. long. The working side of the conveyor is supported by five roller-troughing idlers, pitched about 3 ft. 6 in. apart, whilst the return idlers are about 10 ft. apart. The usual working speed of the band, as mentioned, is 400 ft. per minute, at which it will handle the iron ore at the rate of 1,000 tons per hour, with a maximum of 1,500 tons.

The steel structure supporting the conveyor consists first, of a short horizontal gantry covered with a corrugated iron roof to accommodate the horizontal portion of the conveyor beyond the tunnel. The inclined portion is housed in a similar gantry 10 ft. wide and about 8 ft. 6 in. high, covered with corrugated sheets and open at the sides, the principal support of which is a steel tower 53 ft. high, which by guy ropes supports the cantilevered end of the gantry, with the delivery shoot. The end thus supported projects beyond the tower for a distance of 75 ft., and for a distance of 30 ft. beyond the quay wall. The driving and tightening gear of the band are likewise located in this tower, alongside which there is a small engine and boiler-house.

As will be seen from the illustrations, a large ore dump has been provided on the hillside, slightly hopper-bottomed, with a tunnel under in order to accommodate the horizontal portion of the conveyor, of which 158 ft. are within it. This tunnel is 8 ft. 10 in. high and 9 ft. wide, allowing a convenient passage for the attendant at one side. The roof of the tunnel is formed by steel joists (about 3 ft. apart) and concrete. There are frequent openings communicating by shoot with gates between the dump and a travelling feeding carriage which runs on a rail track over the conveyor. The feeding carriage is shown both in plan and elevation, and in the latter view in dotted lines also in the two extreme positions in which it can feed the conveyor.

The travelling feeding apparatus and the valves are the outcome of careful study, they are a special feature of Messrs. Fraser and Chalmers, Limited, and are greatly contributory to the success of the plant, as it

is by no means easy to feed such material as iron ore which is sometimes in very large pieces, uniformly and gently on to a conveyor; the former attribute is essential to the capacity of the conveyor, while the latter will increase the life of the belt. The fact that the conveying band now in use is still at work, eight years after the plant was started, is proof positive that the problem of feeding the material on to the band to the best advantage by this portable carriage has been successfully achieved. The feeding device has to be attended by two men, who see that the ore does not cave over and thus become hung up instead of passing through the opening in the roof of the tunnel, the carriage can be placed at will under any of the outlets.

The running costs of this particular conveyor with its high capacity are, none the less, exceptionally low, as one might almost expect, next to no driving power being required for running the plant beyond the gravity of the material handled. As we have seen above, only three men are employed to manipulate the plant, two in the tunnel and one at the brake; these men are Spaniards, and their daily wage totals 7*s*. The belt, which is the most important item in the economy of such an installation, was chosen of the best quality, hence its long life. It has withstood not only the severe test imposed by the handling of large ore of a hard and cutting nature, but also, as can be realised from the illustrations, the exposure to the extremely hot climate of Spain, the salt air, and very often, sea spray, which testify to its remarkably good quality. The long life of the belt is, however, due, not only to its excellent quality, but also in part, to the care in the designing of the complete plant, and the attention it has received from the engineer in charge.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting held on Friday, November 23, at the Imperial College of Science, Mr. W. R. Cooper, M.A., vice-president, in the chair, a paper entitled "*Some Problems of Stability of Atoms and Molecules*" was read by Professor J. W. Nicholson, F.R.S.

The paper is mainly concerned with the possible existence and stability of atoms, and of molecules formed after the manner suggested by Stark, the link between the atoms in a molecule being provided by a stationary electron on the molecular axis. Atoms on the Rutherford model, though dynamically unstable, are stable for the simple vibrations ordinarily excited; but it is shown in the Paper that atoms with such a stationary electron have a much more limited degree of stability. Moreover, they cannot exist even in an undisturbed state unless they are endowed with a negative charge, for no steady motion is possible, and this conclusion extends even to atoms regulated according to a dynamics such as that of Bohr. Stark's conclusions do not, therefore, survive a quantitative treatment, and molecules cannot be formed in the manner he supposes.

The paper also discusses the more symmetrical problem, in which there are two such stationary electrons in an undisturbed atom, and it is shown that systems with a transitory existence, which are known by their spectra to occur in the solar corona, are apparently unaccompanied by the still more transitory systems which would be formed by the attachment of an electron after the manner of Stark. This is a further argument against the possibility that two atoms in a molecule can be linked by a single electron, or by two electrons, which attract both atoms.

Discussion.—Mr. T. Smith asked if it would be possible to make some such generalisation as that symmetry in the system was essential to stability.

Dr. Borns asked what was meant by the statement that the atom with $+5e$ and $-7e$ is strongly represented in the solar corona.

Dr. R. S. Willows said it was of great advantage that eminent mathematicians were investigating the suggested models of the atom and attempting to compare the results with experiment. Stark had made some brilliant experimental discoveries, but his theoretical deductions appeared to be faulty.

Professor Nicholson, in reply, said he thought some such generalisation as that suggested by Mr. Smith could be made. At any rate, the greater the symmetry of the system the more liable it is to be stable. In reply to Dr. Borns, he meant that certain lines of strong intensity in the spectrum of the corona were referable to such a system.

An Exhibition of the Uses of Certain Methods of Classification in Optics was given by Mr. T. H. Blakesley, M.A.

This consisted of an account of the additions which, in the course of the intervening years, he had been enabled to make in the general diagram of optical properties, first communicated by him to the Physical Society in the year 1903 (Proceedings, vol. xviii, page 591). The plan pursued is to take as variables the relations which the radii of face curvature bear to the thickness between the faces along the axis. By this means the shape of the lens is given by the two rectangular co-ordinates alone, and any possible property dependent upon a function of these co-ordinates will be represented by a line upon the diagram. When two such loci intersect, the lens corresponding to the points of intersection possesses both the properties corresponding to the lines. A point much dwelt upon by the author was the very large number of straight-line loci corresponding to properties of value in a lens, and of these very many are parallel, and, cutting the axes at 45 deg., may be most simply defined by the value of the intercept of the axis.

It was pointed out that, in general, a lens may have its radii of face curvature both multiplied by the same factor without changing in sign or value the focal length. One of the above-mentioned loci at 45 deg. to the axes represents the only family in which this change cannot be effected, from the fact that the factor in this case is unity. Another of these straight lines belongs to a family in which the two focal lengths corresponding to two assigned indices of refraction are equal: and closely allied to this is a family for which the focal length is a minimum for an assigned value of index.

In another family of the kind the property is that a lens may be immersed in another medium without having its focal length changed. In another, if a lens is cut out of a cylinder of glass, the remnants of the cylinder in their original position will be achromatic. In another, telescopic: and so for many others. Other straight lines exist which are not parallel to those above-mentioned. They often refer to matters connected with the passage at minimum deviation through a lens, and sometimes to what are called self-conjugate points.

The detection of lens properties which are independent of one of the face curvatures was explained and some few cases pointed out—*e.g.*, when a lens has one of its radii of face curvature equal to the thickness of the lens at the axis, it matters not what curvature is given to the other face, the point of magnification equal to the index will be coincident with its own conjugate point—*i.e.*, for the point of magnification equal to the inverse of the index for the other side of the lens: and this whichever way the light is passed through the lens.

There are two lines upon the diagram, both straight lines, which refer to the silvering of the second surfaces of lenses, so as to produce plane virtual mirrors: one performs this by sending the centre of the virtual mirror to infinity, the other by sending the surface of the virtual mirror to infinity. In the latter case, which alone calls for special remark, light, though entering the system at an angle, returns upon the same path, always producing an inverted image of -1 magnification, crossing the object at the virtual centre.

Discussion.—Mr. T. Smith suggested that the author might add a number of curves to his diagram showing the aberration properties of lenses. There were a number of other geometrical loci that might also be added. It usually happened that the lenses required in actual instruments had too long radii in comparison with the thickness to be included in the region covered by the author's diagram, and it was usually better to calculate each lens by known methods than to extract them from a diagram.

Mr. S. D. Chalmers said he had on occasion found diagrams somewhat similar to Mr. Blakesley's, but in which the inverse of the radii of curvatures were employed, to be of considerable service in certain problems.

Mr. Blakesley did not think Mr. Chalmers' system would lead to so many straight-line loci as his own. He thought straight-line loci had some advantage if they could be obtained.

Personal.—With a view to centralising their business in London the Stanton Ironworks Company, Limited, have opened an office at Maxwell House, Arundel-street, Strand, W.C. 2, and matters relating to their coal and cast-iron foundry business will be dealt with at this office. The foundry agency arrangement between the company and Messrs. Beck and Co., Limited, is being terminated at the end of this year, and after December 31, 1917, all communications with reference to castings should be addressed to the company at the above address.

Trading with the Enemy.—A new Consolidating List containing the names of over 3,500 persons and firms with whom persons in the United Kingdom are forbidden to trade under the Trading with the Enemy (Statutory List) Proclamation, 1916, has just been issued. Every one engaged in foreign trade is under an obligation to make himself familiar with the Statutory List and to observe it in his dealings. In exceptional cases where it appears to be necessary and where it is not contrary to the public interest, a licence may be obtained from the Foreign Trade Department, Lancaster House, St. James, S.W. 1, exempting from the prohibition. Copies of the Consolidated List and of all additional lists may be obtained at a small cost from the Superintendent of Publications, His Majesty's Stationery Office, Imperial House, Kingsway, W.C.

Norwegian Shipping Notes.—The Norwegian yards are working with much energy. The largest vessel so far built in Norway was recently launched from the Aker yard, a motor vessel of 6,500 tons dead weight, named *Borgland*, and built to the order of the Fred-Olsen Shipping Company. It is 377 ft. long, 51 ft. beam, has three decks and tanks for oil under the entire bottom. The motors will have a capacity of 2,200 horse-power. As an instance of a yard which has shown rapid development, though on a comparatively small scale, the Hölen yard in Larvik may be mentioned. The firm was started in 1911 with a few men, iron constructive work being the first speciality, then shipbuilding was taken up, the first boat, of 1,540 tons dead weight, being launched about a year ago: another boat has just been delivered two boats are in course of completion, and the yard now employs some 200 men and has orders for 10 steamers, from 600 tons to 2,800 tons capacity.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Holidays are, as is usual at this season of the year, interfering with business. Continued scarcity of trucks is hampering distribution, and the heavy home contracts made for delivery of Cleveland pig-iron under the December allocations will fall short, in a certain measure, of completion. Railway companies are carrying only what is urgently needed over the holiday period, and some Cleveland pig-iron producers have unfortunately had to stock output that could not be got away, and that was much needed for consumption. A little more business has been put through in forge iron for delivery over next quarter, but makers are reluctant to commit themselves ahead to any extent. Foreign transactions are very few and small. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge all stand at 95*s*., and for shipment to France and to Italy these qualities are now all quoted at 116*s*. 6*d*.: whilst No. 1 is 99*s*. for home use, and 121*s*. 6*d*. for shipment to the Allies.

Hematite Iron.—Nothing new of importance can be reported of the East Coast hematite branch. The situation is still stringent, but the steady increase of output of basic iron should shortly relieve the position considerably. Home customers continue to receive supplies adequate to minimum needs, but shipments are on only a very moderate scale. Nos. 1, 2 and 3 are 122*s*. 6*d*. for home use, and 147*s*. 6*d*. for export to France and to Italy.

Coke.—With a good all-round demand for coke, and quite a plentiful supply, business is brisk. Substantial quantities are being taken up for local consumption. Average blast-furnace kinds readily realise 33*s*. at the ovens, and qualities low in phosphorus command 35*s*. 6*d*. at the ovens. Gas coke keeps in keen demand for export at 37*s*. 6*d*. and upward, and the export price of foundry and furnace coke is 45*s*. f.o.b. Middlesbrough Dock.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel have still very heavy orders to execute for the Government, and for the shipyards. Works are closed this week, so that opportunity has been afforded for carrying out very essential repairs, and renewals to plant. Quotations are very stiff. To home customers, common iron bars are 13*l*. 15*s*.: best bars, 14*l*. 2*s*. 6*d*.: best best bars, 14*l*. 10*s*.: iron ship plates, 15*l*. 10*s*.: iron ship angles, 13*l*. 15*s*.: packing iron and steel (parallel), 13*l*. 10*s*.: packing iron and steel (tapered), 15*l*. 15*s*.: steel bars (no test), 14*l*. 10*s*.: steel ship plates, 11*l*. 10*s*.: steel ship angles, 11*l*. 2*s*. 6*d*.: steel boiler plates, 12*l*. 10*s*.: steel joists, 11*l*. 2*s*. 6*d*.: and heavy sections of steel rails, 10*l*. 17*s*. 6*d*.

The Reconstruction of the German Merchant Navy.—Some of the large German shipping concerns have recently placed orders with German yards for more than 150,000 tons. This is, no doubt, the first effect of the new German merchant navy aid measure, and the fact of the first instalment of 300,000,000 marks having been asked for. Another move for the financial assistance of German shipping, is the impending creation of a ships' loan bank, with a capital, to begin with, of 10,000,000 marks, subscribed by some of the leading banks, the new bank is not intended to confine its work to seagoing vessels, but will also assist the river traffic. The Oder yard, in Stettin, is again increasing its capital, this time so as to make it 4,000,000 marks.

The Electro-Technical Industry of Japan.—Japan has been working hard, and under favourable conditions, during the war, and amongst other branches of her industry, that of the electro-technical industry has made important strides. As an example, may be mentioned large capacity electric generators of say, 10,000 kw. which before the war always were imported from England, America, or Germany, but which are now being made within the country. The aggregate value of electro-technical machines and appliances annually manufactured in Japan, has been tripled during the war and now amounts to between £3,000,000 and £4,000,000. The export of electric plant and apparatus also shows a material increase, especially to China and Dutch India, and Japan already holds the fifth place in the matter of export of incandescent lamps.

Pyrites Mines in the United Kingdom.—It is officially announced that the Ministry of Munitions is prepared, during the period of hostilities, to purchase iron pyrites mined in the United Kingdom. The pyrites must contain not less than 37½ per cent. of sulphur, and not over 1 per cent. of arsenic. The price payable will be 35*s*. per ton of pyrites f.o.r., for quantities of not less than one truck load, but the Minister reserves the right to revise the price after December 31, 1918, or if over 5,000 tons are delivered from one deposit, before that date, the price may be revised in respect of further deliveries, from such deposit forthwith. In the first instance, samples of all ore tendered will be selected by the local agent of the Ministry, and if, upon analysis, the ore proves suitable, payment of 75 per cent. of the amount of the purchase price for each consignment will be made on receipt of the railway company's certificate that the pyrites has been put on rail. The balance will be paid within 16 days of the receipt of correct accounts. Producers can obtain detailed particulars on application to the Department of Explosives Supplies, Storey's Gate, Westminster, S.W.1.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The last week of the year is always a busy one in the West of Scotland, and the present is no exception to the long-established habit, there being a feverish anxiety to get as much as possible of the work on hand sent out before the shops close down for the New Year holidays: Government, of course, is still the principal customer for all grades of finished and semi-finished steel, the keenest pressure being for high tensile steel bars and shipbuilding material, with ship plates in urgent demand. The necessity for increasing the output is now more vital than ever, and everything possible is being done to accomplish this before the holidays. While the works are closed, opportunity will be taken to execute the repairs rendered necessary by the long-continued severe and constant strain on machinery and plant so that all may be in readiness for further activity when the workers resume after the brief respite from toil. Imported raw material continues scarce, and will probably become more so, as America is no longer a dependable source of supply. Some small lots are occasionally put upon the market, but the rapidly increasing home production is serving the purpose remarkably well. Still, no announcement has been made regarding increased prices due to additional on-cost, and the idea gains ground that the question will be dealt with as a subsidy, dating from the advance in the cost of coal, coke and other fuel.

Malleable Iron Trade.—Little change has taken place in the malleable iron trade during the week, work being plentiful and the activity intense. Despite the fact that the utmost productive capacity has now been reached, makers continue to find difficulty in preventing arrears of work accumulating. Prompt delivery cannot be assured, and naturally, the most important claims are dealt with first. Prices remain much on the level of last week.

Scotch Pig-Iron Trade.—There is no diminution in the demand for pig-iron of all grades, hematite in particular being so active that the supply meantime cannot keep pace even with the local requirements, which are insatiable. The scarcity of certain brands is distinctly felt, No. 3 foundry quality especially so. Export is practically out of the count at the moment, although the small shipments put through command strikingly firm prices.

The Mid-Scotland Ship Canal.—At a large and representative gathering held in the City Chambers, Glasgow, the two alternative schemes for the construction of a Mid-Scotland Ship Canal were reported upon by Sir Wm. G. Armstrong, Whitworth and Co., as prepared and submitted by them to the Admiralty. The two schemes deal with the Loch Lomond route, and the direct or Bonny and Kelvin route. In opening the proceedings, the Lord Provost of Glasgow expressed the opinion that the interest in the projected ship canal had, up till now, been more academic than vital. The schemes were explained by Rear-Admiral Sir Charles Ottley, director of Sir William G. Armstrong, Whitworth and Co., and Mr. William Kidd, chief of the civil engineering department of the same firm. The discussion which followed was taken part in by a number of prominent men connected alike with the commercial and civic interests of both East and West of Scotland. All phases of this important question were touched upon, and, as a result of the conference, the interest in the proposed ship canal has been greatly stimulated. No resolution was formally put to the meeting, and treasurer Mr. Barrie, in moving a vote of thanks to Messrs. Armstrong, Whitworth and Co., and to Sir Charles Ottley and Mr. Kidd, said that, while that was a noncommittal meeting, he was sure it had served a very useful purpose. In conclusion he remarked that as the canal would be built with public money, it was up to the public to see that it got the best value possible for the money invested.

TIN REGULATION.—In exercise of the powers conferred upon him by Regulation 30B of the Defence of the Realm Regulations, the minister of Munitions specifies tin as being a metal required for the production of war material, and therefore subject to the provisions of that Regulation.

SPITZBERGEN COAL FROM A SWEDISH POINT OF VIEW.—In some comments upon the Swedish coal mining enterprises at Spitzbergen, Professor Gunnar Andersson first draws attention to the immense rise in the prices of coal so that Spitzbergen coal now fetches 20 times the price which was paid for it at Tromsö in the year 1911, the prices being, respectively, 12.75 kronor, and about 240 kronor per ton. This rise in the value of fuel has given a decided impetus to the production of both coal and peat in Sweden, the increase since 1913 being, respectively, 200,000 tons and 400,000 tons. The Spitzbergen coal fields are of considerable capacity, although the actual extent has not yet been accurately ascertained. In 1911, however, the capacity was estimated at 8,750,000,000 tons of coal, the quality of which, according to analysis, is quite satisfactory. The conditions for mining the coal are relatively favourable. A man is calculated to be able to get 1½ to 2 tons per day, and the drawbacks arising from the large accumulation, resulting from the discontinuance of shipping during the ice period, is to a great extent outweighed by the fact that the mines are so located, that the construction of quays can be dispensed with. A time of two to three months must be reckoned upon for a steamer's trip there and back, provided suitable tonnage is employed. Finland, northern Russia, and Scandinavia are likely consumers for Spitzbergen coal.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Christmas Holidays.—After a spell of heavy work, most of the large engineering establishments closed down at the week-end for a period of ten days, which not only will enable the workers to restore their strength, but will afford an opportunity for the management to effect shop repairs and renewals of plant which have become very necessary after the recent speeding-up. In the smaller shops the stoppage is for a shorter period, the general arrangements having been for four or five days. The steel situation is as tense as ever, though the demand on export account has been somewhat lighter. Tool steel, both for home engineering and for the munition works is in heavy demand. The Government continue severely to restrict the export of all steel material, and local makers generally express the opinion that the embargo is more severe than is necessary, and is likely seriously to affect the future from an economic point of view. A somewhat serious blow has been received by the cutlery industry in the new Order classing shell discard steel as war material. This steel has been very largely in use for knife making, and has been the means of keeping together a substantial volume of trade. With practically no ready substitute available, the restriction is bound to cut down an industry already seriously starved. Permits will doubtless be granted to make all the cutlery necessary for purely war purposes, but public supplies will be found increasingly difficult to obtain.

South Yorkshire Coal Trade.—Business was very slack on Sheffield Exchange immediately preceding the holidays. In house fuel especially there was little doing, consumers having apparently laid in sufficient stocks to see them over Christmas. There was, however, little free coal on offer, and any spot lots were quickly snapped up. The works continued to press for full deliveries on contract account, and showed anxiety to obtain stocks to tide them over the first few days after resumption of work. Best steam coal has come to hand fairly freely, while cobbles, nuts and slacks are in strong demand. A big tonnage of gas coal has been going away on contract account, and companies still complain that they are short of supplies. Stocks have had to be drawn upon at an earlier period than usual, and pressure is being brought to bear on the collieries to increase the output. Slacks are firmer than ever, the demand being always in advance of the supply. The demand for export is heavy, but the control is firm, and confined to Allied countries. Immediately preceding the holidays there were heavy shipments to France and Italy. Quotations:—Best branch handpicked, 23*s.* to 24*s.*: Barnsley best Silkstone, 23*s.* 6*d.*: Derbyshire best brights, 21*s.* to 22*s.*: Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*: best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*: Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*: small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*: Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*: best slacks, 14*s.* to 14*s.* 6*d.*: seconds, 13*s.* to 13*s.* 6*d.*: smalls, 9*s.* to 10*s.*, all at the pits.

GERMAN CHAMBER OF COMMERCE.—One of the latest German Government interferences with trade is in connection with an altered composition of the Prussian Chambers of Commerce, which are henceforth to be known as Chambers of Commerce and Industry. The German Chambers of Commerce have in the past devoted a fair amount of attention to the country's industry, perhaps more than similar institutions in other countries, but they are for the future to have a proportionate representation for industry, and, at the option of its department in question, separate sections, or sub-sections, can be formed for certain important branches. The representatives are chosen respectively by commerce and industry, but the decisions of the chamber have to be arrived at by joint voting. The aim is increased co-operation, an increased centralisation of the country's productive powers. The Chambers for Commerce in Germany have played a part of increased importance during the war, and this movement is likely to be continued and extended in the times of peace.

FLOTATION IN COPPER METALLURGY.—If general estimates be trustworthy, flotation has made enormous strides in the United States in spite of the peculiar legal aspect of the patent rights. According to Mr. T. A. Rickard, editor of the *Mining and Scientific Press*, of San Francisco, 30,000,000 tons of ore are now being treated by flotation per annum. As regards copper in particular, the Anaconda Copper Mining Company states that their loss of good ore now, with flotation, amounts to a little over 4 per cent., whilst it was 17 per cent. with modern gravity concentration: concentration losses of 20 per cent. and flotation losses of 8 per cent. or more seem to be the average, according to a communication by Mr. E. P. Mathewson, of the British America Nickel Corporation in Toronto, published in the *Journal of Engineering and Industrial Chemistry* of November. Flotation, which was still considered unsuitable for copper ores after it had proved a success with zinc ores, has solved the slime problem, the bugbear of copper metallurgists. The same journal also contains a longer article on the "Chemicals used in Flotation," by Messrs. O. C. Ralston, of the Bureau of Mines, and L. D. Yunelf, of Utah University. The theory of flotation in general is still controversial, and the action of certain chemicals is particularly so. The chief chemicals used in flotation are sulphuric acid, lime and alkalis (caustic soda, sodium, carbonate, sodium silicate), sodium sulphide and sulphate, calcium sulphate, copper sulphate, silicofluorides, sulphur dioxide; sodiumcyanide is generally regarded as deleterious, but it has also been proposed and tried.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Markets.—The markets closed at midday on Monday, until Thursday morning, and during the first three days of the week a general holiday was observed throughout the West coalfield. Stocks had accumulated to an abnormal extent, but it is anticipated that the congestion will be materially relieved by the time the pits resume work. It is expected that the Coal Controller will issue his long-promised new directions early in the New Year. Those published in October were expressly only of an interim character, and it is fully anticipated that the new directions will involve a general revision of the scheduled prices. The Admiralty collieries have been conceded an increase on coals supplied for Admiralty purposes, so that at present France and Italy are getting their supplies at a smaller cost than that at which our own Navy is getting its coals. Moreover, the current scheduled prices are nothing like high enough to meet the present cost of production, and this fact, in itself, is a sufficient reason for an early revision.

Newport.—There is really very little to report this week in view of the holidays. It is, however, of interest to note that negotiations are just now in progress with the object of establishing a fixed price of 65*s.* per ton for imported pitwood. Probably it will be some time before these negotiations are brought to a head, and it will be of little use attempting to establish any limitation in the absence of a definite arrangement in regard to the price at which imported timber is shipped on board at the French ports.

Supplies of Coal to France.—A draft scheme for the pooling of supplies of coal to France was submitted to a meeting of exporters on the Cardiff Exchange on Friday of last week. It was proposed that the arrangements should be on somewhat similar lines to those which are now operative in connection with the Italian supplies. The scheme, however, did not commend itself to the French coal exporters, and it was consequently rejected. After the proposal had been defeated on a show of hands on the part of those present, it was decided to take a vote on shipment basis. This vote resulted as follows:—

Against the scheme	...	...	9,696,484
In favour of the scheme	...	...	6,552,709
Majority against	...	...	3,143,775

EXPANSION OF GERMAN STEAMER COMPANIES.—The Hamburg-Bremen-Africa steamer line in Bremen has decided to increase its capital from 5,500,000 marks to 10,000,000 marks. It is also proposed to alter the statutes, so that for the future directors and members of the board must be German subjects.

ROLLED BRITISH STANDARD SECTIONS.—We have received from the Controller's department, Admiralty, Great George-street, S.W.1., a list of steel sections (angles, bulb angles, channels, bulb plates, tee bars and joists), which has been adopted, after conference between the Admiralty and Ministry of Munitions, as sufficing to cover all practical requirements, both in ship, bridge and building construction, &c., for the duration of the war. It is desirable that information as to these sections should be generally known, in view of the fact that there is little or no prospect of any other sections being available during the period in question. It obviously follows that all designers and consumers will do well to base their requirements on this list, with a view to the avoidance of disappointment and delay.

GERMAN WAR PROFITS.—The Hannover Machine Company, after providing for war tax reserve, has earned a surplus for last year of 14,584,741 marks against 12,163,777 marks for the year 1915–16, the turnover having risen from 51,300,000 marks during the latter year to 67,700,000 marks for the year 1916–17. Owing to the rise in the price of raw materials, in wages, &c., the profit for last year is proportionately smaller than that for the previous year. The net profits have receded from 6,043,402 marks to 5,701,707 marks, but the general costs have risen from 3,456,013 marks to 6,283,033 marks, and a sum of 450,000 marks to employees in the previous year had to be deducted from the net profits, whilst in this balance sheet this item has been deducted prior to fixing the net profits. The dividend was again fixed at 30 per cent., accounting for 2,400,000 marks. A sum of 1,100,000 marks has been expended in the purchase of a site for additional extensions. The works were fully employed. The Gute Hoffnunshütte at Oberhausen shows gross profits of 35,797,711 marks for last year, which is a decrease compared with the figures for 1915–16, when the gross profits amounted to 43,372,849 marks. After writings off, amounting to 9,529,702 marks, some 700,000 marks less than the previous year and after other items having been provided for, the net profits amounted to 19,326,348 marks, against 24,168,816 marks for the previous year, and a dividend of 20 per cent. was again declared. A sum of 7,000,000 marks was added to the reserve, started in the previous year with 5,000,000 marks, and 500,000 marks were added to the officials' fund. The turnover in all departments experienced a material increase in the year 1916–17. The Germania Ammunition Works pay 14 per cent. dividend for last year and are increasing the capital from 1,200,000 marks to 2,500,000 marks. The Ludwig Hupfeld Company in Leipsic last year earned an available surplus of 2,175,266 marks against 508,779 marks for the previous year, a dividend of 20 per cent. being declared against 6 per cent. for the previous year. The current year promises well, and orders are as plentiful as last year.

REINFORCED CONCRETE CONSTRUCTIONS; MARRIOTT SYSTEM.

CONSTRUCTED BY MESSRS. J. ELLIS AND SON, LEICESTER.

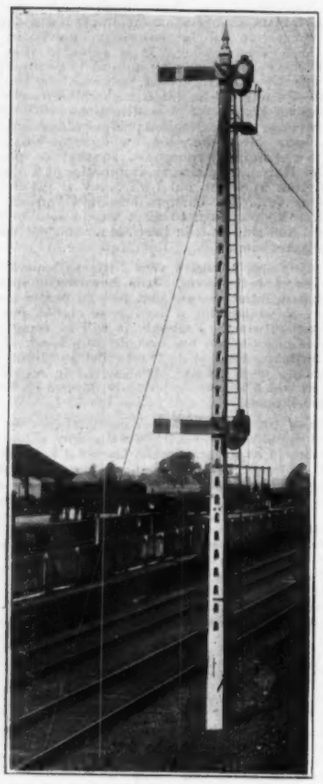


Fig. 1. High Signal Post, M.R.

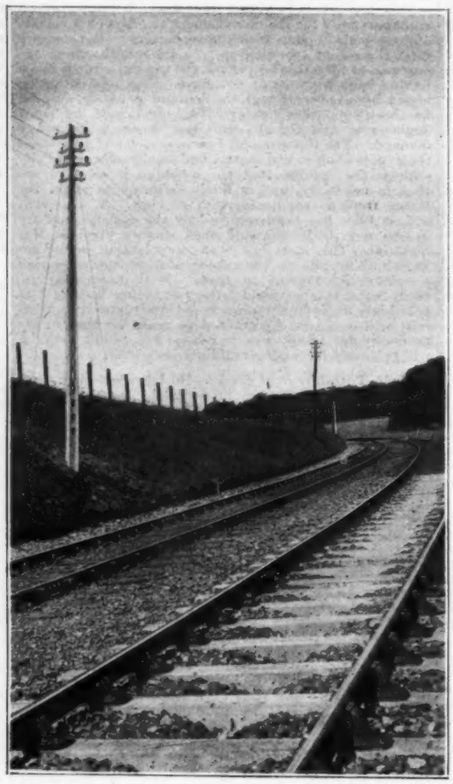


Fig. 3. Hollow Concrete Sleepers.

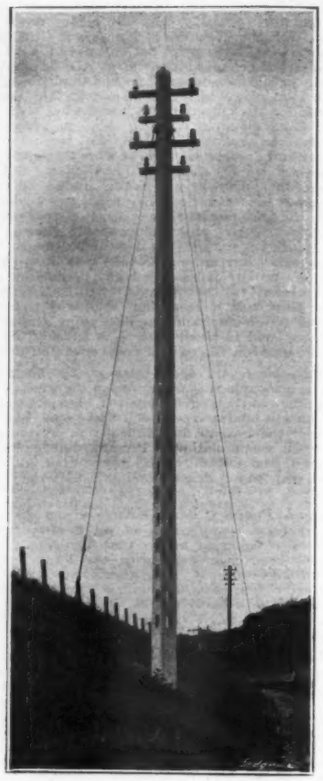


Fig. 4. Triangular Hollow Telegraph Post.

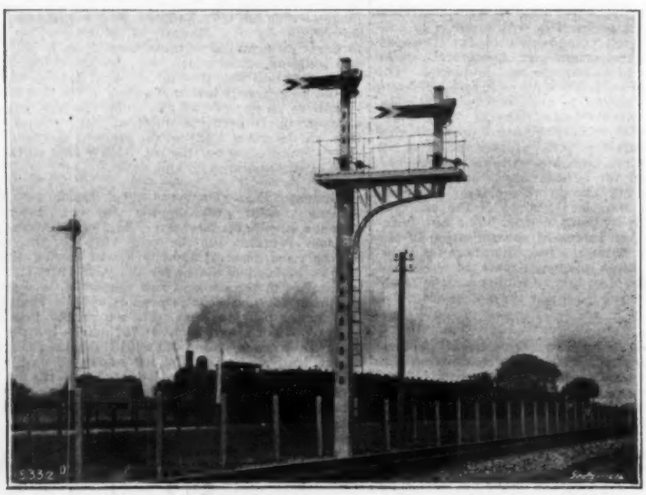


Fig. 2. Great Northern Post with Standard Iron Bracket.

Fig. 5. Station Name Board in Coloured Concrete.

Owing to the war we are faced with an alarming shortage of timber, and there is a probability that even after the conclusion of peace, this shortage, with the consequent high prices, may continue for several years. More attention than ever, therefore, has been devoted to ferro-concrete, which rightly used can, and does, in so many ways replace timber. Specially valuable, from this point of view, are those forms of concrete constructions which lend themselves to repetition work, by which many can be made in the same sets of moulds. Owing to the high price of timber massed concrete *in situ*, needing much shuttering, is getting more and more costly, so that the tendency of all designs should, and must be, towards standardisation, and consequent repetition.

One of the principal defects of concrete, of course, is its weight. Bulk for bulk, it is three or four times the weight of the wood it replaces. For the reduction of weight the design needs modification as much as possible. With the Marriott system of reinforcement it is possible so to design most posts, standards, girders, beams and sleepers that they shall be only a little more than double the weight of the wood they replace, and yet still be sufficienty strong.

Various methods of reinforcement have been employed, none of which, however, lends itself readily to the production of the smaller and less heavy things which are daily demanded by the engineer. Directly the reinforcement is elongated or deflected by any movement in the parts undergoing tensile stress, the concretec racks, and the article is, if not ruined, so damaged that its ultimate life, which would otherwise be a long one, is appreciably shortened—although it had probably been regarded as an absolutely permanent construction, as indeed well designed and reinforced concrete should be.

The aim should be so to dispose the steel in form and quantity as to take tensile stress without permanent elongation or deflection, so that the article may be capable

REINFORCED CONCRETE CONSTRUCTIONS; MARRIOTT SYSTEM.

CONSTRUCTED BY MESSRS. J. ELLIS AND SON, LEICESTER.

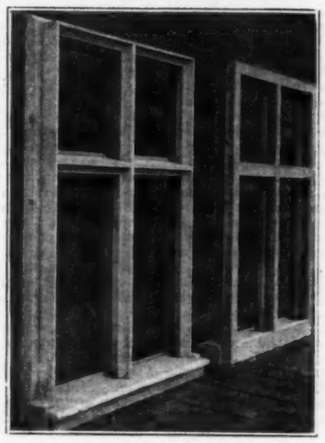


FIG. 6. CONCRETE WINDOW FRAMES.

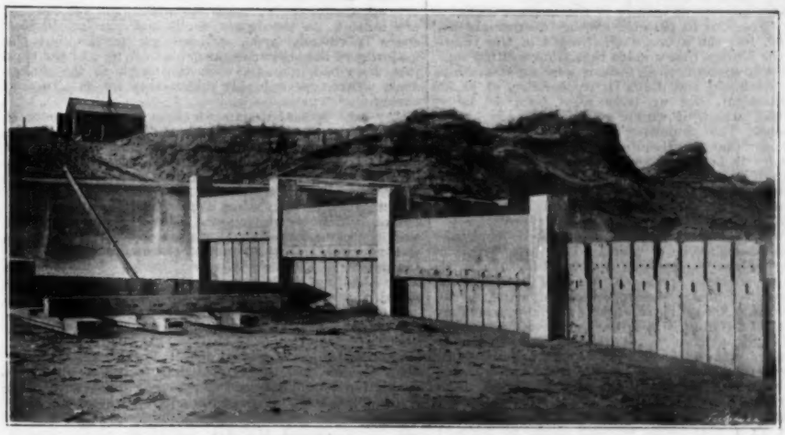


FIG. 7. REINFORCED CONCRETE GROYNE.

of bearing transverse stress without cracking. For this, the steel must be of high tensile quality. A fence post, with no special stress to meet, can be very simply reinforced; but a straining post, with a pull of 8 to 10 wires, may have a load of several tons put upon it. Indeed, it was the failure of these posts to take transverse stresses that led to the devising and patenting of the Marriott system. By this system four or more main rods, parallel or tapering, are placed longitudinally, these being each connected with continuous bracing rods, so arranged that they form with the main rods a series of reversed triangles on two opposite sides of the reinforcement structure; while angularly disposed ties on the other two sides permit the perforation of the concrete article without loss of strength, and give it a light and elegant appearance. The point of contact of the braces with the main rods is staggered in every case, the maximum amount of support being thus obtained, along with a considerable stiffening of the whole structure. A special feature of the design is the securing of the bracing by welding at each point of contact. The whole thus forms a perfectly rigid structure which cannot get out of shape, or be misplaced in the liquid concrete during process of manufacture, as can, and does, occur so easily with reinforcements attached only by binders.

The whole reinforcement can be designed and accurately calculated, so that the whole of the metal is distributed round the extreme fibres where the stresses are greatest: this enables articles of reasonable dimensions to be cored to the fullest extent, greatly reducing weight without appreciably reducing the strength. When transport or erection are in view this is a most important factor, and one which immediately removes what has been a signal drawback in the employment of concrete.

A simple test, on the average of three ordinary fence posts 4½ in. by 3¾ in., made in the ordinary way with ½-in. main rods and usual binders, compared with three reinforced on the Marriott system showed the ultimate load carried by the M.R.C. system to be 28 per cent. higher, while the general deflection was 20 per cent. less, and the maximum deflection, previous to collapse, 130 per cent. more. These just ordinary fence posts (not designed as beams or girders) were tested by being placed on supports 5 ft. apart, a gradually increasing load being applied in the centre.

The patentee, Mr. W. Marriott, M.Inst.C.E., who was one of the earliest advocates of concrete as a preservative of steel, has frequently buried steel in concrete during his thirty-five years' experience on railway construction and maintenance, and he has invariably noticed, when such work had to be altered for widenings some years afterwards, how well the steel was preserved. (See Marriott on the "Strengthening and Maintenance of Early Iron Bridges." Pro.Inst.C.E., Vol. clxii., Session 1904–5, Part 4.)

On nearly all the principal railways some hundreds of concrete signal posts are either already up or are about to be erected. Telegraph poles, too, both square and triangular, have passed the preliminary stage. The great blizzard of March, 1917, left a M.R.C. signal post still standing while trees near by had been blown down.

A few of the uses to which the Marriott concrete constructions have been put may be gathered from the illustrations on this and the opposite pages.

Fig. 1 illustrates a high signal on the Midland main line. This is specially interesting as showing how easily adaptable the design is to additions. The post was made as a single arm post, whereas, as will be seen, a second lower arm has easily been added.

In Fig. 2 the bracket type of post is shown. The main post here is hollow, and consequently not so much heavier than wood. The post is made to fit the standard and existing G.N. iron bracket. The dolls are also concrete.

Fig. 3 shows a stretch of Marriott hollow concrete sleepers in the main running road on a grade where a good speed is run at times, and also where brakes are put on. On the opposite side of the cutting is seen the triangular hollow telegraph post, illustrated in Fig. 4. These are being made for at least two important railways and are specially suitable for heavy lines. They have already attracted a good deal of favourable notice. These telegraph posts are made to take a safe wire pull of 240 or 480 lbs. or more if required.

The double station name board illustrated in Fig. 5 is a neat instance of what can be done in coloured concrete; it is made on a somewhat new principle and is very effective and also cheap and, of course, durable, requiring no painting. The window frames and sill all cast in one piece (Fig. 6, above) are perhaps one of the best examples of how in every-day and general building work, wood can be economically dispensed with. These identical frames have displaced wooden ones needing urgent renewal.

Fig. 9 is perhaps one of the most interesting, showing a concrete groyne in course of construction. The king piles are 15 in. by 12 in. and the sheets 12 in. by 6 in. hollow and filled with concrete *in situ*, thus ensuring a complete sealing up of any cracks which may have developed during transport or driving as is often the case, and so preventing the sea water from getting at the reinforcement. All these examples are made of excellent materials, no breeze, slag, clinkers, or any material likely to contain sulphur being used in their manufacture.

All the above designs are carried out on the Marriott system, they are covered by patents in various countries, and are further protected as registered designs. The sales agent for these constructions is Mr. W. Jones, 154–5, Upper Thames Street, and Messrs. J. Ellis and Son, Leicester, are the manufacturers and licencees.

THE SCANDINAVIAN AIR TRAFFIC PLANS.—At a recent meeting of the Aeronautical Society in Stockholm, the Crown Prince, the Premier and other Ministers being present, Captain Dahlbeck gave a survey of aeroplane traffic so far as Sweden was concerned. Denmark has no air traffic society yet, but a large new factory for aeroplanes is in full swing. Denmark is interested in comprehensive international schemes, such as England-Denmark-Sweden and Germany-Sweden-Norway, that is as an intermediate link. In Denmark the legal side of the question, the protection of national territory and the granting of concessions, seems in the meantime to attract much attention.

RECENT DEVELOPMENTS IN TANK STEAMER CONSTRUCTION.*

By ROBERT W. MORRELL, M.E., Member.

THE growth of the American tank-steamer fleet since the beginning of the European War has been so remarkable, and the tank steamers now represent such a large and important part of our merchant marine, that the construction of these vessels cannot fail to be a subject of interest in maritime circles. At the end of the year 1914 the tank steamers under American registry numbered about 80 (exclusive of barges), of 278,837 gross tons and approximately 416,000 tons deadweight, which at the time represented only about 10 per cent. of the total steel tonnage of the United States, excluding the Great Lakes and sailing vessels. At that time shipbuilding in this country was almost at a standstill, and the outlook was very gloomy. So complete was the cessation of activity in the shipyards that this period of depression may be said to represent the line of demarcation between the old shipbuilding era and the new. Early in 1915 shipbuilding took on a new lease of life, and it is interesting to note that it was the construction of tank steamers which started most of the yards on their new road to prosperity. It was the need for oil carriers which rescued the shipbuilding industry and revived it.

Since the beginning of 1915 there have been built in this country 57 tankers (exclusive of barges), of 371,900 gross tons and 519,200 tons deadweight, thus more than doubling the American tank steamer tonnage. It will also be noted that the average tonnage of the individual vessels shows a great increase over that of the vessels previously built. In addition to the extensive building programme carried on, a marked addition to the American tanker fleet was made under the provisions of the Panama Canal Act of August 18, 1914, by means of which 40 foreign-built tankers, aggregating over 190,000 gross tons or 285,000 tons deadweight, have been transferred to American registry. We, therefore, have the honour of displaying the American flag from the largest tank ship afloat—the German-built steamer Jupiter, now the Standard, of 10,073 gross tons and 17,000 tons deadweight. The second largest tanker is a British vessel of 15,500 tons deadweight, while the United States ranks third, having constructed a type of vessel of 15,000 tons deadweight. It might be mentioned that six vessels of this size have already been turned out in this country, and that four more are nearing completion. Up to the present date we have lost six tankships through war causes. Two of these were German-built, three British-built and one American-built. They represent a gross tonnage of 26,537 and 38,590 tons deadweight.

The total number of American tankers now in service is therefore about 170, having a total gross tonnage of 823,200 and a total deadweight carrying capacity of 1,180,000 tons. Thus it will be seen that during the recent period of activity the number of tank ships has been increased 112 per cent., the gross tonnage increased 185 per cent. and the total deadweight tonnage increased 185 per cent. Not only is this the case, but it is also found that the tank steamer tonnage is now close to 20 per cent. of the total steel American tonnage (exclusive of the Lakes), as against 10 per cent. at the beginning of 1915, thus indicating that the greatest of the recent progress in shipbuilding has been in the construction of tankers, and that the growth of the oil industry has demanded for them a prominent part

* Paper read at the meeting of the Society of Naval Architects and Marine Engineers, New York, November 15.

in our shipbuilding programme. In addition to this impressive fleet of tankers, we now have under construction in the United States a total of 64 tank vessels, representing 496,680 gross tons and 575,750 tons deadweight, marking the greatest shipbuilding activity in the history of the country. This recent construction on so large a scale could not fail to bring out interesting and instructive features deserving of comment.

The most impressive feature of the modern tanker is the size. Previous to 1915 the average deadweight was 5,200 tons, but the average deadweight of the vessels built in the United States since that time is 9,100 tons. In 1915 the largest American tankers were the steamships John D. Archbold and John D. Rockefeller, of 11,500 tons deadweight, but we have since built 10 larger vessels, the largest of which attain a deadweight of 15,000 tons. The shipowner's faith in the economy of the large tankers, therefore, appears to be firmly established. In fact, under certain conditions, the large vessels, trading at ports having limited depth of water, and therefore obliged to load part cargoes, have been able to compete with smaller vessels whose light draught permits loading full cargo.

Along with the increased size came the development of the shelter-deck type of vessel. The term "shelter-decked type," as commonly used in this country in referring to tankers, applies to a vessel having three continuous steel decks, the uppermost of which is the strength deck. According to Lloyd's Register, a shelter-decked vessel is one in which the uppermost or shelter deck is a light, continuous superstructure, with one or more tonnage openings. If without tonnage openings, it is an awning-decked vessel, while if the upper scantlings are heavier it becomes a spar-decked vessel. The commonly accepted use of the term "shelter-decked vessel" in this country, however, is in reference to any vessel having a continuous weather deck, as opposed to the type having raised forecastle, bridge and poop. The first shelter-decked tankers built in this country were the sister ships John D. Archbold and John D. Rockefeller, of 11,500 tons deadweight each. These vessels had the oil tanks carried up to the upper deck, which is the next deck below the shelter deck. The oil hatches were located on the upper deck, and gas trunks were built around the hatches and extending from upper to shelter deck, to keep the gases from permeating the 'tween-deck space. Experience has proven these trunks a source of danger to the ships, as the heavy gases accumulate at the hatches and great caution is necessary to prevent men from being overcome when entering the tanks. Apparatus for clearing these spaces of gas has since been installed.

The next step in the development of the shelter-decked type was the carrying of the expansion trunks right up to the shelter deck. This was embodied in the Charles Pratt, and subsequent vessels of that type, with great success. With this arrangement, the expansion-trunk bulkheads extend from the second deck (or main deck or tank deck, as it is variously called) up to the shelter deck, thus making the expansion trunk two decks in height. The summer tanks are arranged outboard of the expansion trunk between the second and upper decks. The oil hatches for both main and summer tanks are located on the shelter deck, and small trunks, extending between the upper and shelter decks, are built for the summer tanks. Outboard of the expansion trunk, between the upper and shelter decks, are open 'tween-deck spaces above the summer tanks. The principal advantages of this design over that in which the oil is not carried above the upper deck are as follow :—

1. An increase of about 10 per cent. to 15 per cent. in the cubic capacity of the tanks is obtained, which is of great benefit when carrying light grades of oil.

2. The vessel can be trimmed when loaded with much better results, as the expansion trunk extending through two deck heights gives great scope for the desired ullages. If the vessel has a tendency to trim by the head when leaving port, on account of full fuel tanks forward, this can be overcome with the present design by leaving large ullages in the forward cargo tanks and smaller ullages in the after tanks. It is also possible, as fuel is used, to maintain any desired trim by transferring the cargo. The deep trunks allow great leeway in this respect.

3. On account of the oil hatches being on the shelter deck, the danger of getting gas in the 'tween-deck space is avoided.

4. The centre of gravity of the cargo is higher, making an easier ship.

5. The expansion trunk and centre-line bulkheads, extended up to the shelter deck, provide valuable additions to the longitudinal strength of the ship.

To offset the above, it should be noted that additional steel is required to carry the trunks to the shelter deck, and that the scantlings must be increased on account of the increased head of oil. Therefore a slight increase in the hull weight is involved, and, if the vessel is to carry only heavy crude or fuel oils, the extension of the oil space above the upper deck is not advisable. This brings out the fact, which is constantly cropping up, that to design the most economical tankers they must be specialised for particular trades and used in no other trades. The point just mentioned illustrates this—if the vessel is intended to carry light oils, the oil space should be made as large as possible by extending it up to the shelter deck; but if intended to carry only heavy oil, large cubic space is not required, and the oil space may terminate at the upper deck.

It should be noted in passing that with the oil hatches on the shelter deck it is not advisable to locate the living quarters amidships directly on the oiltight deck. To overcome this, on all vessels of this type the accommodations have been raised 3 ft. 6 in. off the shelter deck, leaving an open space under the house. The house plating is extended down to the deck on the front and sides, but is open for access at the after end. The house with this construction requires particularly secure fastening to the shelter deck. It is impossible to avoid bringing up some of the valve-operating rods into this space under the house, but, these are extended out clear by means of bevel gears.

There have recently been built, or are now building, several shelter-deck vessels in which the oil hatches are located on the upper deck, and the 'tween-deck space is entirely open, without gas trunks, but the majority of the shelter-decked ships are now of the type just described, namely, with the trunk to the shelter deck. This type is highly satisfactory for an all-round tanker.

A recent special design which is worthy of note is embodied in the tanker D. G. Scofield, in which the entire 'tween-deck space, between upper and shelter decks, is made suitable for carrying case or barrel oil, in addition to the bulk cargo in the tanks. The oil hatches are on the upper deck and large cargo hatches are provided in the shelter deck each side of the centre strake, which is continuous. Three masts are fitted with complete cargo-handling gear consisting of booms and winches. This is another instance, however, of adaptation of a tanker to special trade. Such package cargo-handling equipment on the majority of tankers would be useless.

In considering the subject of shelter-decked tankers, the question naturally arises as to what determines whether a vessel shall be built with a shelter deck or a forecastle, bridge and poop deck. The answer is somewhat obscure, but the determining factors seem to be mainly matters of size and of personal preference. The dividing line seems to be in the neighbourhood of 10,000 tons or 11,000 tons deadweight, the vessels above that size being almost without exception shelter-decked vessels. The main point involved is one of draught. In increasing the size of the vessels it is not desirable to increase the draught in proportion. The shelter-decked type lends itself to carrying an increased deadweight on a limited draught without adopting extreme proportions. The shelter-decked type is also preferable for strength purposes in the larger sizes.

With regard to tonnage openings, a few shelter-decked vessels of this nature have been built, and they have the advantage of small tonnage measurement combined with good structural design due to small length to depth ratio; but the greater depth required tends toward a heavier ship. For purposes of comparison I have made a rough approximation of the general characteristics of four steamers, each of 11,000 tons deadweight capacity, but of different types, as follows : (1) Shelter-decked vessel with expansion trunk carried to shelter deck; (2) shelter-decked vessel with oil space up to upper deck only—no tonnage openings; (3) same as (2) but with tonnage openings; (4) forecastle, bridge and poop type. In working out the dimensions the length and beam were kept constant and the depth and draught allowed to vary to suit the different conditions.

The following table gives the results of the calculations, which have not been carried out to any degree of refinement, but which are sufficient to indicate what may be expected of the different types :—

Comparison of Four Types of Tankers of 11,000 Tons Deadweight Each.

Type.	L.	B.	Draught.	Depth to Upper Deck.	Depth to Shelter Deck.	Displacement.	Weight of Ship, Light.	Cargo Capacity.	Gross Tonnage.
	ft.	ft.	ft. in.	ft. in.	ft. in.			cub. ft.	
1	450	59	26 4	28 0	35 6	16,270	5,270	483,000	7,900
2	450	59	25 6	27 10	35 4	15,700	4,700	420,000	7,850
3	450	59	26 0	31 0	38 6	15,800	4,800	458,000	7,750
4	450	59	26 6	34 0	—	16,000	5,000	460,000	7,850

From the table it will be noted that type (1), although a heavy ship, has great cubic capacity, and is therefore best adapted to carrying light grades of oil. Type (2) is a lighter ship, for reasons previously explained, but has small cubic space, and is therefore suitable only for heavy oil trade. Type (3), on account of the tonnage openings, requires great depth, resulting in increased weight of hull and increased cubic capacity. Type (4), it will be noted, requires greater draught and is rather heavy, but has plenty of room inside. It must be remembered that all of these vessels will carry a deadweight of 11,000 tons, and therefore the variations and possibilities with the deadweight fixed, and even with length and breadth fixed, are apparent. The results go to show that the vessel when designed must be made to conform to the conditions under which it is intended to operate. In the matter of cubic cargo space, for instance; let us assume that for a vessel of this size the fuel carried will be 1,050 tons, with 250 tons fresh water, stores, &c. This leaves 9,700 tons for cargo, which, if heavy fuel oil, occupies 358,900 cub. ft.; if refined oil, 436,500 cub. ft.; and, if naphtha, 485,000 cub. ft. A study of these figures will readily give an indication of the respective capabilities of the vessels. The foregoing types were assumed to have the usual sheer line, the middle portion of which, if faired on the ¼-in. lines, would show an easy curve. It must be noted, however, that there is a growing tendency at present to adopt a straight sheer line amidships, and in fact there are tankers now under construction embodying this idea.

In order to investigate the effect of the straight sheer, the sheer line in type (1) was changed and made straight for 55 per cent. of the length amidships, fairing in to the original height at the ends. This change made an increase in the moulded depth to shelter deck of 2¾ per cent. The principal objection to the straight sheer is the reduction in height of shelter deck for a space beginning at the stem and extending to a point about 35 per cent. of the length abaft the stem, where the old line crosses the new. The greatest reduction in height occurs between 15 per cent. and 20 per cent. of the length abaft the stem. The reduction amounts to only a few inches and is not a serious difficulty. With the new sheer line, the allowable draught will not be noticeably changed, and the difference in hull weight will be negligible. The advantage structurally of the straight sheer is obvious, as it will permit practically universal work throughout almost the entire length of the oil space, and the frames, bulkheads, &c., will be alike for every tank except the end ones.

A prominent feature of recent construction has been the subdivision of the cargo tanks into groups for the carrying of different grades of oil. If two different grades are separated by a single bulkhead there is danger that a leak in the bulkhead, permitting a mixing of the grades, will spoil the cargo. The first step was to place the pump-room amidships, which, aside from being a most convenient location for pumping, divides the tanks into two groups in which different grades of oil can be loaded without danger of mixing. This was carried further, and cofferdams inserted between the tanks. The 15,000 tons deadweight tankers previously mentioned have 10 main cargo tanks divided into three groups with a separate pumping system for each. Several smaller tankers have similar divisions. This is another example of the incorporation of special requirements for special trade. As an extreme case, there is one vessel now building on the Atlantic Coast which has five cofferdams and a pump-room dividing the cargo tanks into four separate blocks. One of the cofferdams, however, is located between the after fuel-oil tank and the fire-room. Many of the modern tankers have this arrangement, which is a wise safety precaution originated on account of fires started by oil in the fire-room, due to leaky bunker bulkheads.

Where such cofferdams are built, they are provided with tunnels for use in the event of the vessels burning coal. The tunnels are blanked by oiltight bolted doors on each end, but if used for coal the oiltight doors will be removed and vertical sliding bunker doors fitted. The fuel-oil piping passing through the cofferdam is fitted with a valve on each bulkhead, the valve on the bunker side being controlled from the deck. The cofferdam is also provided with a sea valve controlled from the deck, for flooding in case of fire. Thus, if a fire originates in the boiler-room, it can be isolated from the fuel supply, while if the fire starts in the tanks the propelling machinery can be kept intact.

An important feature of the tank steamer situation is the construction of steamers with cylindrical tanks. Six of this type of vessel have been built or are being built by the Chester Shipbuilding Company. Aside from the saving in hull weight in this type, it has the advantage that the cylindrical tanks can be constructed by people other than shipbuilders. Under the present conditions this fact bears considerable weight. The present design shows a series of tanks, the diameter of which is as great as the vessel's framing will permit. A recent design which places smaller tanks on opposite sides of the centre line appears to have an advantage with regard to preventing listing of the vessel. If it is desired to carry cargo or ballast outside the cylinders—that is, between the cylinders and the ship's sides—it is important that the head of water or oil outside the cylinders be not greater than that inside, and for this purpose automatic non-return valves are provided. The cylindrical tanks are particularly well adapted to conversion jobs, and the few recent conversions of general cargo vessels to tankers have been on this basis. It is a remarkable fact, in view of the great demand for tank tonnage, that so few vessels have been converted to bulk-oil carriers, and rather reflects the sceptical attitude of the shipping community toward converted vessels.

Returning to the ordinary tanker and coming down to structural features, it appears that the greatest single item which made for better construction has been the adoption of rolled tee-bar section for oiltight work. Until recently, tee-bar was not generally rolled for ship use, and was unobtainable in proper sizes. Under pressure from shipbuilders and shipowners, however, the mills have adopted this section in several sizes, and the advantages of its use in the construction of tankers are generally recognised. Tee-bar is now being used for the bracket connections of longitudinals to bulkheads, and is replacing single and double-angle connections for this purpose. It has the advantage of being made oiltight much more readily than the angle connections, for the double-angle clips have a habit of leaking at their ends, and the single-angle clip gives difficulty along its heel. The usual size of tee-bar for bracket connections is 6½ in. by 6½ in. by 0.45 in., double-riveted in both flanges. Where this replaces a single-angle clip, 3½ in. by 3½ in., single riveted, it is apparent that an equal number of rivets can be obtained in a much

shorter tee-bar clip. It is inadvisable, however, even with equivalent rivet connections, to reduce the depth of the brackets on account of using shorter tee-bar clips; and the tendency is therefore to use longer tee-bar clips than the riveting requires in order to maintain the effective portion of the brackets.

A further use of tee-bars is for bounding connections on oiltight work. On some of the shelter-decked tankers just built, in which the expansion trunk is carried to the shelter deck, the bar is used to connect the upper-deck plating to the expansion-trunk bulkheads, with excellent results. If a single angle were used instead, the heel would require to be caulked for the entire length. Tee-bar is also being used to connect the top of the fore deep tank (under the forward hold) to the fore-peak bulkhead and to the forward cofferdam bulkhead. The shell connection, where the heel need not be caulked, is angle bar, and this butted against the tee-bar and straps fitted. The Sun Shipbuilding Company is using tee-bar for the boundaries of the transverse oiltight bulkheads, and, while the writer has approved this as an emergency measure, there is some question whether double bounding angles are not necessary to maintain proper oiltightness. The use of the tee-bar for bilge-keel attachments has long been established as the only thoroughly satisfactory connection, and recent experience has indicated that these tee-bars should be at least $\frac{5}{8}$ in. thick. One other feature is of great importance for oiltight work, namely, the multiple punch. This has not been used extensively up to the present, but its possibilities are so great that it is believed this machine will soon be in common use in building tankers.

The first requirement for oiltight work is that the rivet holes shall be fair—a result which, unfortunately, is not always obtained with the common single punch, especially when operated by a gang on piece-work. By using the multiple punch, the holes are spaced mathematically correct; every space is exactly the same as every other, therefore the holes cannot fail to match when the work is erected. If, therefore, the multiple punch will insure fairness of holes, its importance for oil work is obvious. In addition to this advantage, the actual cost of punching, reaming, riveting and testing will undoubtedly be lowered, while the actual laying-off of the work for punching is entirely eliminated where this punch is used. It must be understood that this type of machine imposes severe restrictions on the rivet spacing, and it is only by painstaking care in the original design and in developing the riveting details that the multiple punch can be used. The chief difficulty is that the spacing in frames or longitudinals must be exactly twice that in seams and butts, which may involve some additional rivets not required by the rules. The spacing in way of bulkheads and transverse frames presents a knotty problem, and it may be that some holes will have to be single-punched or drilled. The multiple punch is, of course, only suitable for work on the dead flat, but if properly worked out it can be used on a very large portion of such work, and will result in making the parts universal to a far greater extent than at present.

In view of the large number of tankers recently sunk by submarines, many of which have been in ballast, considerable thought has been given to the question of ballasting in order to give the most favourable conditions if torpedoed. The ballast condition of a tanker is a variable quantity, as it may be altered at will to suit weather conditions or for other reasons. Many claim that if all tanks are filled with water to bring the ship to her load draught and several tanks are then pierced by explosion, the condition of trim and list will be changed but little, whereas if some of the tanks are empty and then pierced the vessel will settle, due to filling the tanks previously empty, and will list as well, due to the additional water on one side only. On the other hand, if water is carried in all the tanks, obviously some of them must be slack tanks and be even more likely to cause listing.

After carefully considering the subject, the writer's conclusions are: First, that no slack tanks should be carried, thereby eliminating this danger from listing Second, that the vessel be given as much reserve buoyancy as possible, which may be the means of saving the ship if torpedoed in the machinery space; therefore, as little ballast should be carried as weather conditions will permit, but whatever is carried should be in full tanks so distributed as to equalise the loading to best advantage. Third, that gate valves be fitted in the centre-line bulkhead near the bottom of each tank, operated from the deck, but left open at sea; thus, if empty tanks are pierced, the water will equalise and prevent listing.

Experience indicates that a torpedo explosion shatters the structure in the vicinity and renders it non-watertight or non-oiltight for a considerable radius. If several tanks are full, the water or oil in them, being practically non-compressible, transmits the shock and destroys the watertightness for a much greater radius. This is another reason for having empty tanks. If the shock of explosion is so transmitted by water in the tanks as to cause the fuel-oil bulkhead to leak into the fire-room, the ship is doomed; therefore, anything making this a possibility must be avoided.

With reference to the subject of standardising, this is a matter which has been in the air for some time, and the standardisation of tankers has been discussed on many occasions. So far as the standardisation of fittings is concerned, there are great possibilities in this direction. It is understood that the Bethlehem Steel Corporation has already taken steps to standardise fittings in its various plants, and it is to be hoped that this will include fittings for tankers, such as oiltight hatches, shell manholes, tank ladders, cargo pipe fittings, valve-operating gear, heater coils, gas vents, &c. It would be of great advantage if standard fittings of this nature could be adopted by all the shipyards in the country. As to standardising tankers themselves, it would be interesting to note that the 64 tank vessels now under construction in American yards represent 19 distinct types or designs, and are being built in 16 different shipyards for 16 different owners, considering vessels building for "foreign account" as being under one owner. At least there were 16 different owners prior to August 3 at which time all these vessels were requisitioned by the United States Shipping Board, Emergency Fleet Corporation. The construction of these vessels is now in the hands of the corporation, represented by the district officers; at the urgent request of tank-ship owners, the district officers have retained the services of the former owners' inspectors, in order that inspection by men thoroughly trained in oiltight work might be assured. The 19 types above mentioned range in size from 5,000 tons to 15,000 tons deadweight and represent almost every possible variation in design. They were designed by competent men to meet specific requirements. Practically every oil company and every shipyard has its own standard type of tanker, or in many cases three or four standard types, all varying in accordance with the different needs of the business and with the different ideas as to how these needs are best met.

It has already been pointed out that special vessels are required for special trades in order to obtain the best results. A vessel designed to carry heavy oil is not suitable for transporting refined oil, and *vice versa*. A vessel designed for straight cargo is not suitable for a mixed cargo, but a vessel designed for mixed cargo is needlessly complicated and expensive for shipping straight cargo. Owners trading on the west coast only, naturally desire to take advantage of the deep water to adopt wholesome proportions of length to depth, whereas other owners, trading in ports where draught is restricted, must adopt different proportions. Some trades require vessels with fuel capacity for 10 days, others for 40 days. In many cases large vessels are the most economical, but large vessels cannot be built in all yards and cannot enter all ports.

It is obviously impossible to find a single vessel to meet all requirements, and if an attempt at a compromise is made it will place practically every oil company at a disadvantage in having to operate vessels which are not quite suitable. The nearest approach to efficient standardisation would be in the adoption of at least four standard designs, consisting of two vessels, a large one and a small one, for the sole purpose of carrying cargoes of heavy oil, and two vessels, a large one and a small one, especially for carrying mixed cargoes of light oil. In carrying heavy oil, such as fuel oil or crude oil, it is possible to load different kinds in the same vessel without danger of mixing, due to leakage or due to pumping one kind through the same pipe line as another. Therefore there is no need of subdividing the tanks for different grades.

The smaller vessel for this purpose would naturally be of the forecastle, bridge and poop type, and the larger one of the shelter-decked type. In both cases small fuel tanks for bunker use are sufficient, as it is possible for a long voyage to carry half a main cargo tank of fuel, or to carry it in summer tanks. The permanent fuel-oil tanks should consist of a short tank at the forward end of the cargo tanks, and another at the after end, thus enabling the vessel to be trimmed as the fuel is used. With this arrangement no cofferdams whatever are required in the vessel. The pump-room in this type of vessel should be located between the after-fuel tank and the boiler-room, thus separating the oil from the fires, and should contain the fuel-oil pumps and heaters as well as two cargo-oil pumps. A simple system of cargo-oil piping, whereby both pumps can draw from the tanks and discharge overboard independently is sufficient. The summer tanks may be fitted with drop-valves, connecting them with the main tanks, or they may be piped for fuel oil, as conditions require. All tanks in these vessels should be fitted with heater coils.

For the standard vessels intended to carry mixed cargoes of light-gravity oils, the smaller would be of the forecastle, bridge and poop type, and the larger of the shelter-decked type with expansion trunks carried up to the shelter deck. In both vessels rather larger fuel-tank capacity is required. On account of the danger in carrying naphtha next to fuel oil, cofferdams should be provided at each end of the cargo tanks. The cargo pump-room should be located amidships, thus dividing the cargo tanks into two groups. For safety, a cofferdam between the after fuel tank and the fire-room should be provided, and the oil-burning apparatus installed in a separate enclosure in the fire-room wing. A fuel pump is required forward to transfer fuel aft from the forward tank. The cargo oil-piping system should permit of the pumping of different grades of oil from the forward and after groups of cargo tanks simultaneously and independently, without the two grades using any piping in common. The cargo piping must not extend into the fuel tanks. The summer tanks should be piped separately. Special precautions against gas must be provided, and the gas vents from the tanks fitted with automatic relief valves. Special ventilation for the pump-room and cofferdams must be furnished.

The foregoing outlines briefly the minimum that could be expected in the standardisation of tankers. Assuming, however, that such standard designs were prepared and approved, it is not clear just what would be gained by throwing out all the present designs and adopting new standard designs. The vessels now building were designed especially for certain definite purposes, best known to their original owners, and it is not likely that standard designs would serve such purposes any better. The ships now building are duplicates of other ships previously built in the same yards, and the experience gained on the previous vessels is an asset not lightly to be ignored. The advantage of having all plans, material orders, templates and patterns for existing vessels places a handicap on standard ships which will take time to overcome, and the result would be to slow up construction instead of speeding-up. Unquestionably, the quickest and most economical means of building additional tankers is to duplicate existing vessels, for which the designs are already perfected and which conform specifically to the needs of the oil business. In this way only can the cheapest and quickest construction and the greatest economy of operation be attained.

The future tank ship construction is, however, an uncertainty. All of the vessels now under construction are for 1917 or 1918 delivery. When these vessels are completed, the building of tank ships will, according to present indications, be at a standstill in this country. So far as we are aware, the United States Shipping Board has not, up to the present time, made any provision for tankers in its shipbuilding programme. The board is promoting the construction of a huge fleet of cargo carriers to transport supplies to our allies and to handle the nation's increasing commerce; but it has entirely ignored one of the most important of the Allies' necessities and one of our own principal industries in excluding tankers from its programme. The nation's oil business has advanced with enormous strides, and is still advancing. The demand for tank-steamer tonnage is greater than ever, and new vessels will be needed constantly to meet the ever-growing transportation requirements. We have lost many tank ships through war causes, and will undoubtedly continue to lose them. In spite of all this, there is no provision for future requirements. Oil companies and shipbuilders have endeavoured to obtain the board's permission to proceed with tank ship construction, but up to date this permission has not been granted. The present situation is, therefore, that the Shipping Board is placing no new orders for building tank ships, and will not permit anyone else to do so. This policy can have but one result, and, if immediate steps are not taken, we shall unquestionably be faced by grave shortage of tank-steamer tonnage. This condition is most serious and urgent, and demands the earnest consideration of all shipping men having the nation's welfare, and the cause in the great struggle which it represents, at heart.

ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this society was held on Wednesday, the 19th inst., at the Society's Rooms, 70, Victoria-street, Westminster, Major H. G. Lyons, D.Sc., F.R.S., President, in the chair. Mr. P. Bolton, M.A., read a paper on "*The Computation of Wind Velocity from Pilot Balloon Observations.*" In this problem the required wind velocities occur as the bases of a succession of triangles in which two sides a, b, and the included angle C are obtained by simple calculations from theodolite observations. To solve such triangles directly by the ordinary slide rule method, the two numbers a, b, on the logarithmic scale must be brought into coincidence on the logarithmic sine scale with two angles differing by the magnitude of the angle C. When this has been done the other elements of the triangle can be read off directly. The paper suggests a means of reducing the labour of setting the scales. A prepared chart of logarithmic sine curves is used which in effect takes the place of the logarithmic sine scale of the slide rule. The other scales are rearranged with a view to reducing the arithmetical work involved in the complete solution of the problem.

A paper by Mr. E. G. Bilham, B.Sc., F.R.Met.Soc., was also read entitled "*The Use of Monthly Mean Values in Climatological Analysis.*" The objects of the paper are (1) to determine to what extent computations based on calendar monthly mean values are vitiated by the fact that the latter are of unequal length, and (2) to provide means of applying numerical corrections on account of errors arising from this cause. The mean month is defined as an exact one-twelfth division of the year, or 30.437 days, and that period is used as the standard to which the results derived from the actual months are reduced. The matter is of special interest in connection with the computation of Fourier coefficients to represent the seasonal variation of a meteorological element such as temperature. Regarding the year as a cycle of 360 deg., errors arise from the fact that the monthly mean values will in general differ by small amounts from the ordinates of the curve corresponding to 15 deg., 45 deg., &c. The corrections to be applied to the original monthly means, and to the Fourier amplitudes have been determined. The use of these corrections is suggested as an alternative to the employment of five-day means in cases where special accuracy is required.

THE INSTITUTION OF CIVIL ENGINEERS EXAMINATIONS.—The Council of the Institution of Civil Engineers has resolved that its examination in engineering drawing, bills of quantities and elementary knowledge of specifications, which is at present an optional subject, shall be after January 1, 1919, obligatory for all candidates for associate membership. The examination is intended to be a suitable test of the knowledge and skill which should be acquired during the requisite training in engineering offices, and will apply to the several main departments of practice. The tests in drawing and quantities may be conducted in part by means of the production of drawings and quantities which have been prepared by candidates under their employers and teachers. Students of the Institution may be allowed to take the examination prior to the time at which they become candidates for election as associate members.

9-IN. CENTRE HEAVY DUTY SHELL LATHE.

CONSTRUCTED BY THE CINCINNATI LATHE AND TOOL COMPANY, OAKLEY, OHIO, U.S.A.

(*For Description, see Page* 699.)

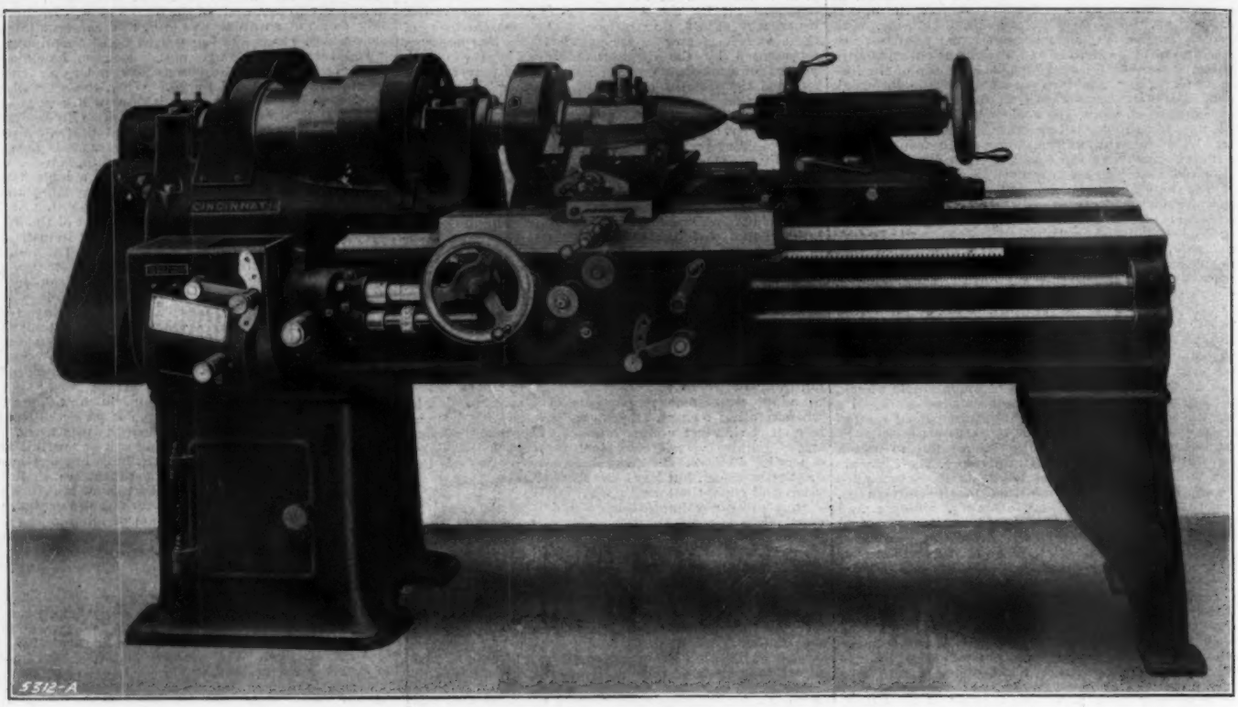


Fig. 1. General View of Lathe, showing Front of Apron and Feed and Thread Index Gear.

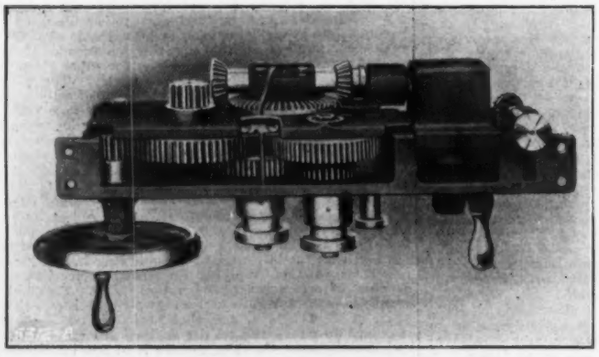


Fig. 2. View of Apron showing Double Support of all Shaft Spurs.

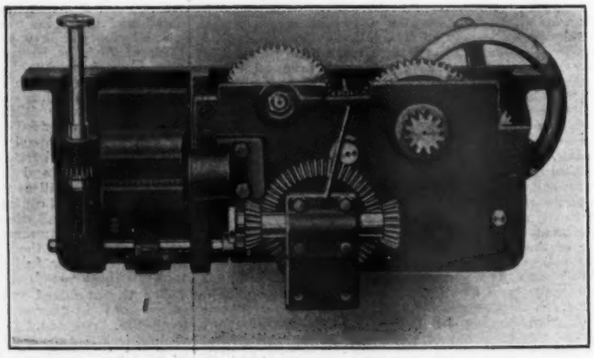


Fig. 3. Back of Apron, showing Feed Reversing Gear.

Tungsten Filaments.—When referring, in our issue of August 31, on page 232, to the method by which the firm of Julius Pintsch produces tungsten filaments in which the tungsten forms crystals several metres in length, which retain their perfect ductility and pliability, so that a lamp wire may be twisted about a very small mandrel after having been glowing for many hours, we remarked that the part played by the thoria in these filaments remained obscure. A few per cent. of thoria are added to the tungsten in order to secure the pliability: and this thoria does not seem to be reduced during the operations. Lecturing upon the same subject recently before the Deutsche Beleuchtungs Technische Gesellschaft, Dr. Schröter suggested that the fine grains of tungsten were at the high temperature to which the treatment exposed them, evaporated at a high rate and that they adapted themselves to the space lattice structure of the larger grains: hence the formation of long crystals. It is generally assumed that the large grains of crystals in crystalline structures grow at the expense of the smallest grains, which have a very high vapour tension. The thoria would support this tendency growing in one direction somewhat in the way that urea added to solutions of sodium chloride, causes the salt to crystallise, not in the well-known cubes, but in octohedrons. The structure of the tungsten filament crystals is now being investigated by Professor Rinne, at Leipzig, by X-ray examination after Lane and Debye. We also mentioned that tungsten is generally supposed to crystallise in four-sided prism, or rather elongated hetragonal trapezohedrons, whilst the etched filaments appear eight-sided. But, Schroter argues, the faces thus disclosed need not be crystal faces. The atoms seem to be arranged in parallel planes at right angles to the main axis, the eight atoms of each plane alternating in successive planes: the etching brings the prism planes out, because the planes in which the atoms are crowded are less soluble than other planes.

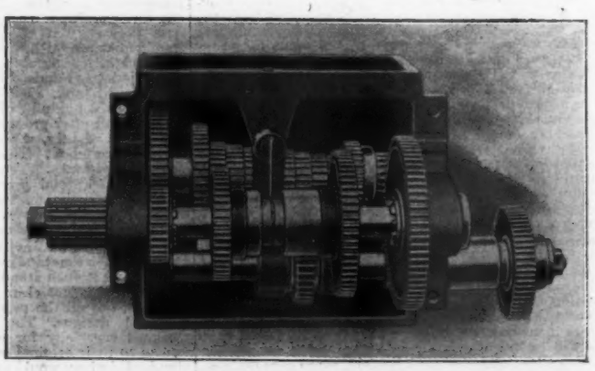


Fig. 4. Interior of Gear Box.

THE AUSTRALIAN TRANSCONTINENTAL RAILWAY.

(*For Description, see Page 677.*)

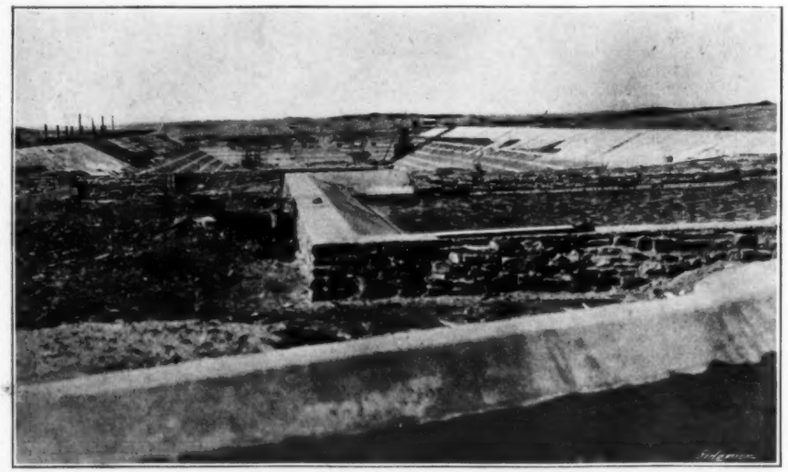


FIG. 2. WIRRAPPA RESERVOIR, SOUTH AUSTRALIA.

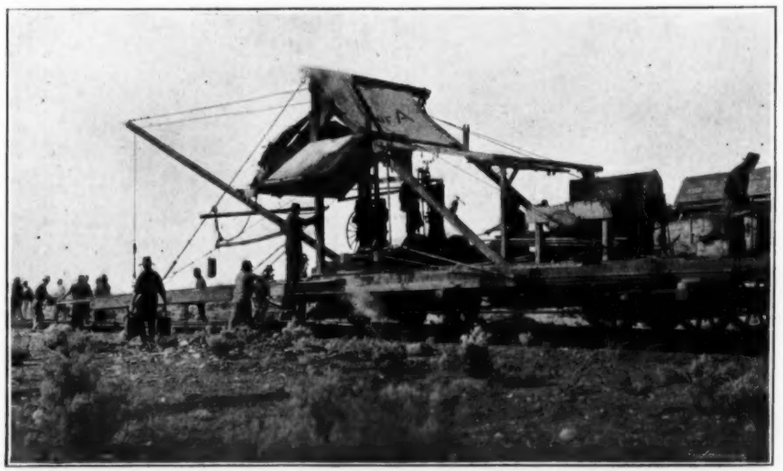


FIG. 3. TRACKLAYER, SHOWING TROUGH CONVEYER.

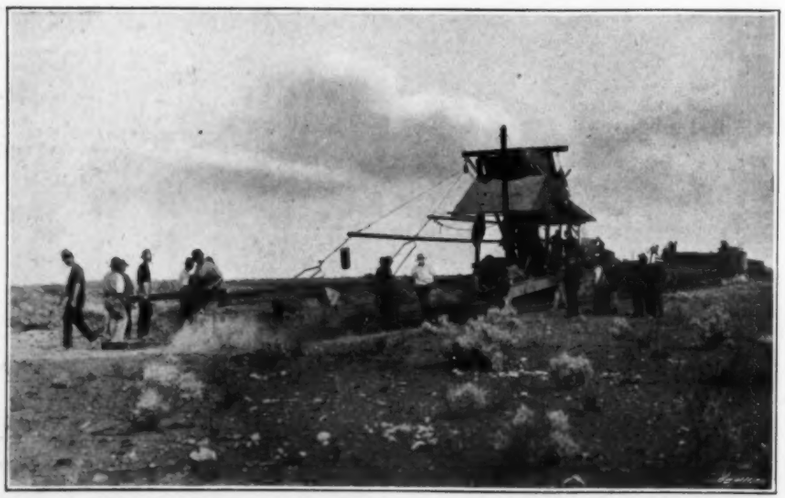


FIG. 4. TRACKLAYING AT HEAD OF LINE

FIG. 5. A WAYSIDE STATION AND INSPECTION TRAIN.

(*To face page 678.*)

THE ARRANGEMENT OF MACHINE SHOPS.

THE WORKS OF MESSRS. DAVID BROWN AND SONS (HUDDFD.), LIMITED, HUDDERSFIELD.

(*For Description, see Page* 679.)

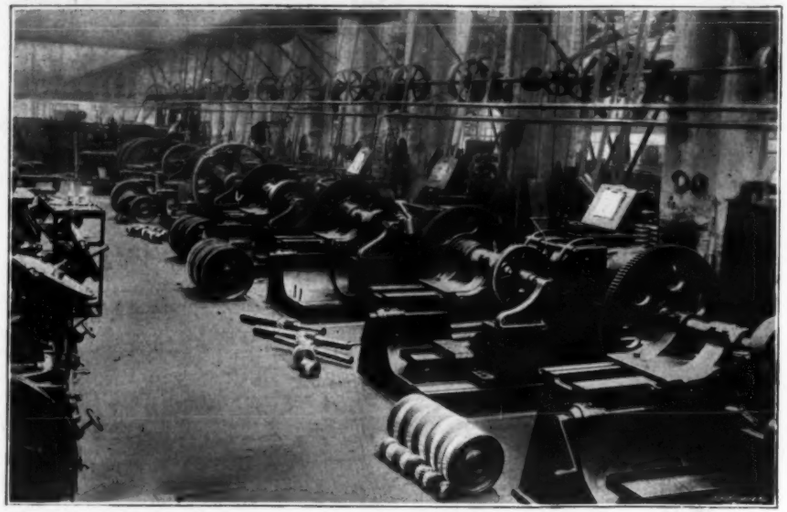


FIG. 217. DOUBLE HELICAL GEAR GENERATING SHOP.

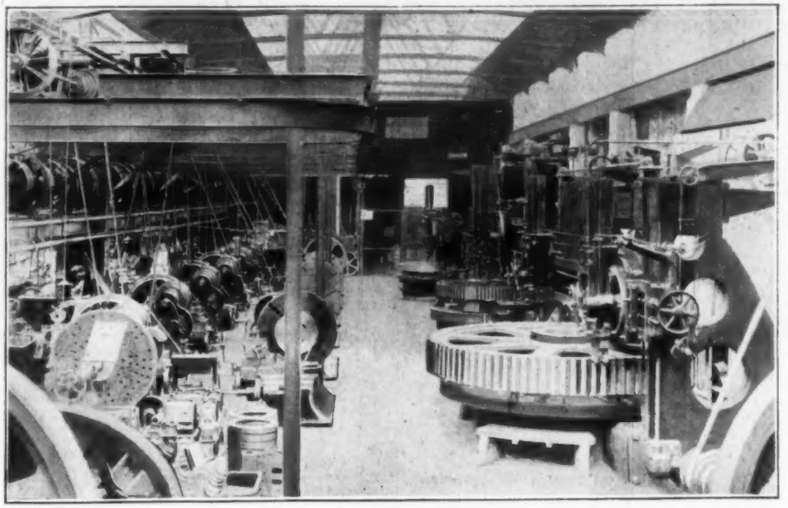


FIG. 219. HEAVY TURNING BAY.

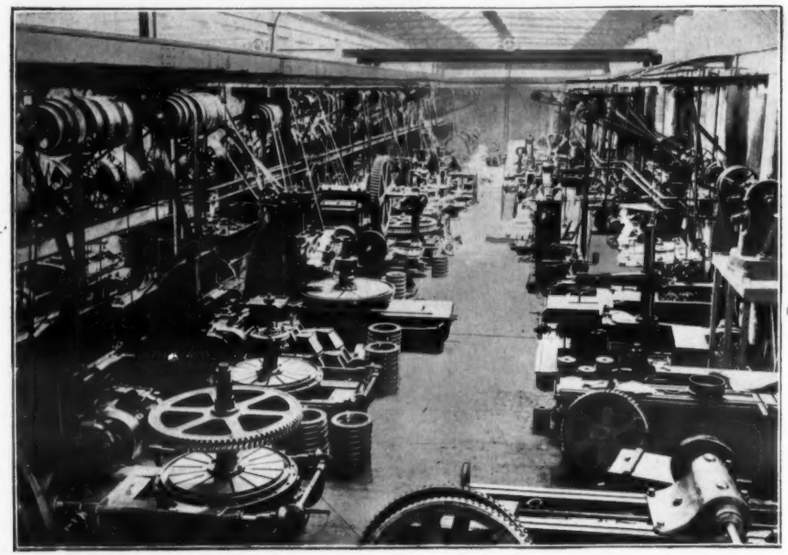


FIG. 218. WORM AND SPIRAL GEAR HOBBING SHOP.

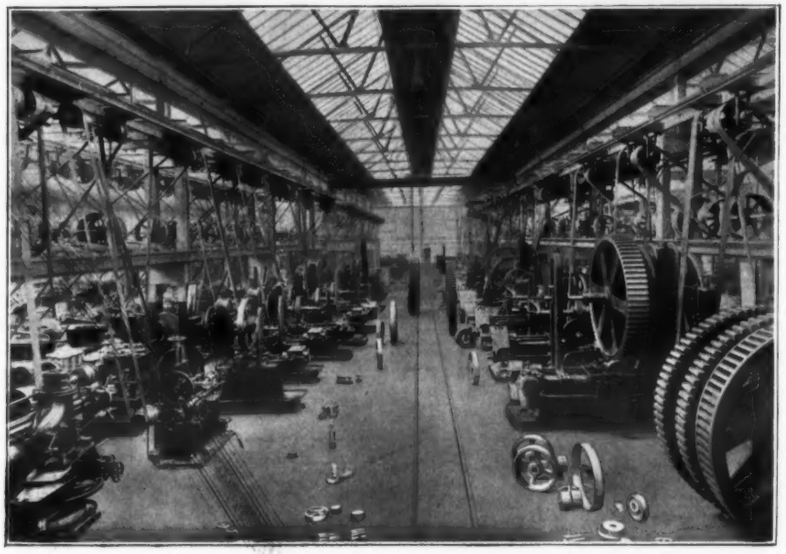


FIG. 220. SPUR GEAR CUTTING DEPARTMENT.

THE ARRANGEMENT OF MACHINE SHOPS.

THE WORKS OF MESSRS. DAVID BROWN AND SONS (HUDDFD.), LIMITED, HUDDERSFIELD.

(*For Description, see Page* 679.)

FIG. 221. WORM MILLING BAY.

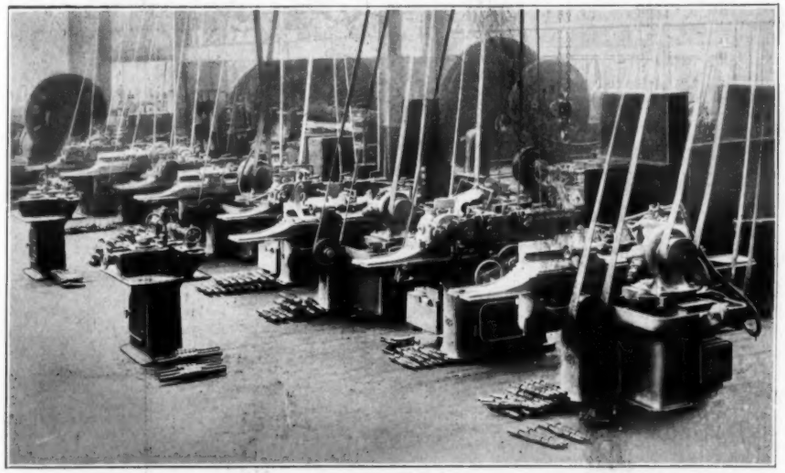


FIG. 223. WORM GRINDING DEPARTMENT.

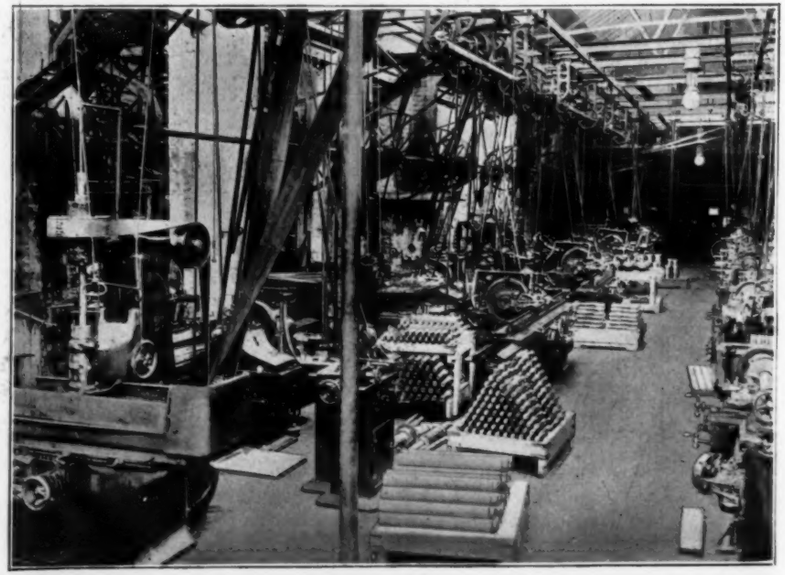


FIG. 222. GENERAL GRINDING DEPARTMENT.

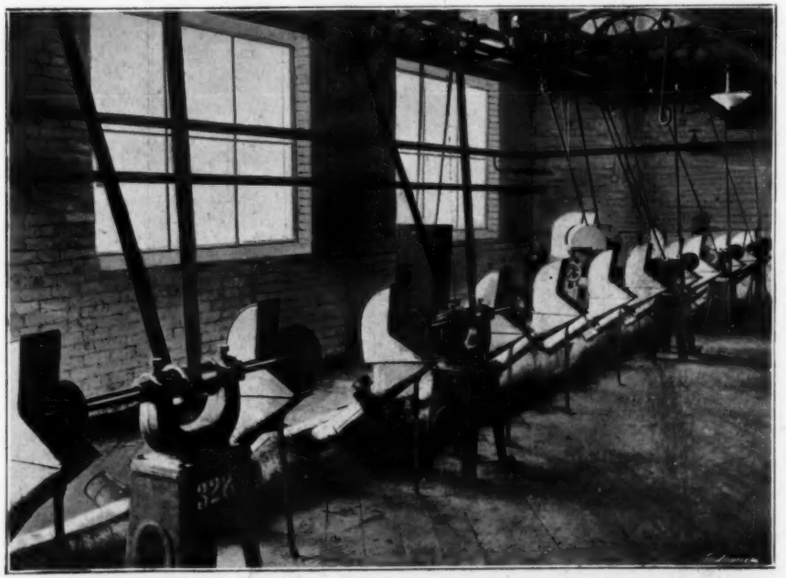


FIG. 224. POLISHING DEPARTMENT.

THE ARRANGEMENT OF MACHINE SHOPS.

THE WORKS OF MESSRS. DAVID BROWN AND SONS (HUDDFD.), LIMITED, HUDDERSFIELD.

(*For Description, see Page* 679.)

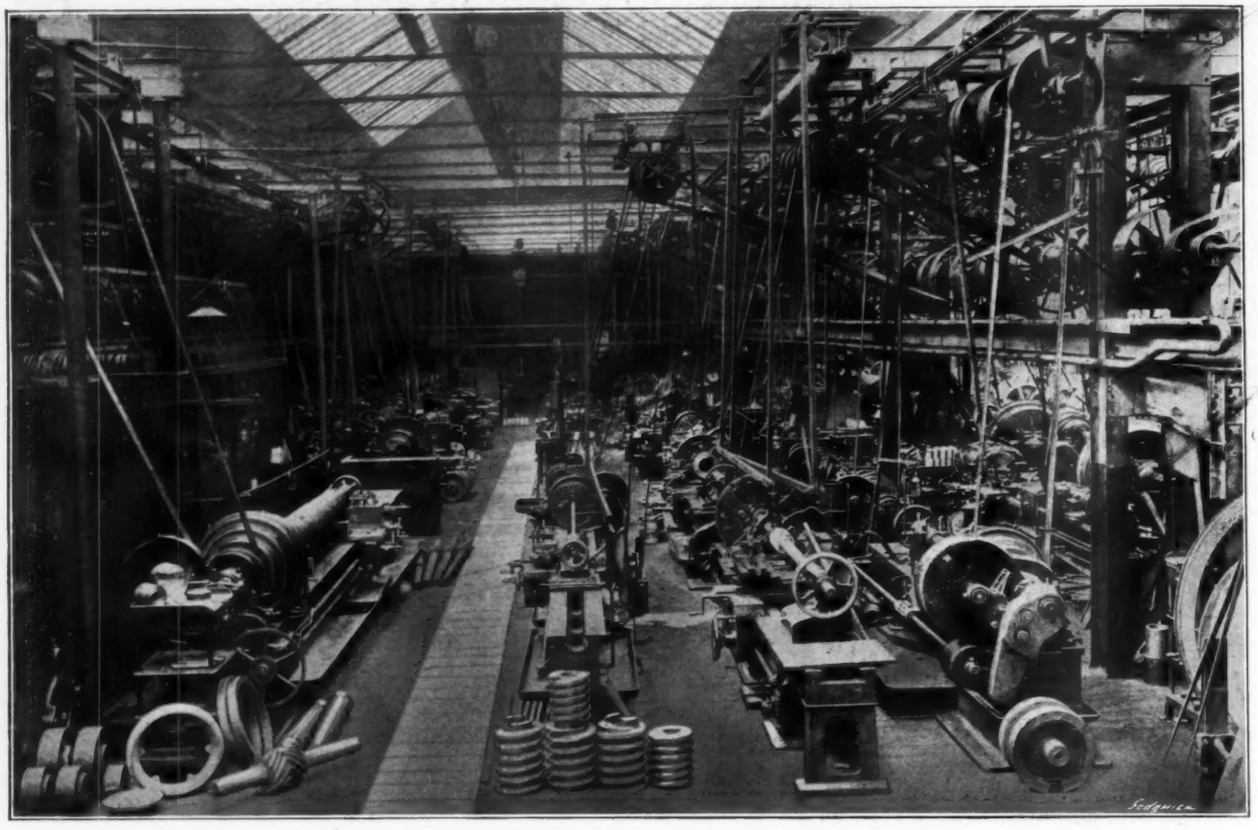


FIG. 225. MAIN TURNING BAY.

FIG. 226. WORM-WHEEL MILLING AND TESTING DEPARTMENTS.

(*To face page* 679.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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With One One-Page Plate of the AUSTRALIAN TRANSCONTINENTAL RAILWAY, and Three One-Page Plates of the ARRANGEMENT OF MACHINE SHOPS.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, DECEMBER 28, 1917.

FACTORS IN THE WORLD TRADE COMPETITION.

THE future race for supremacy in the iron, steel and engineering export trade, the world's most important group of manufacturing industries, will probably be mainly between the United States and the United Kingdom. Before the war the Germans, by means of protection, organisation, subsidisation and hard work, got ahead of us in the steel group of trades, alike in volume of production and in exportation. In the last 30 years before the war the Germans increased their output of iron, steel and engineering products, measured in terms of pig-iron, from 3,000,000 tons a year to 19,000,000 tons. In the same period we only increased our output from 8,000,000 tons a year to 9,000,000 tons. We neither kept pace with growth of population nor growth of demand. The world's *per capita* consumption of iron and steel increased by 150 per cent. Our *per capita* production did not increase by 1 per cent. In the last fifteen years before the war the protected, organised and subsidised German trade increased its exports of iron and steel goods from less than 1,000,000 tons a year to 6,000,000 tons, whilst we, with our much better shipping facilities, our much greater capital investments abroad, our much vaster Colonial possessions and dependencies, and our much more vital need of an abnormal trade in manufactured exports to balance our abnormal food imports—we only in those fifteen years increased our exports of iron and steel from 3,500,000 tons a year to 5,000,000 tons. We lost the lead because we failed to protect our industries, failed to organise, and failed to work hard. Our statesmen would not give productive industry the slightest protection or encouragement, or even the commonest of fair play. Our manufacturers and shippers would not drop their conservatism, or sink their individualism, and co-operate for the common good. Our workmen lost 100,000,000 separate working days by strikes in ten years, they opposed machinery, they limited apprentices, and deliberately "slow-timed" their work. After the war we have to protect and organise and develop our industries on common-sense lines, work diligently, enter into preferential trading arrangements with our Colonies and Allies, and avoid German goods. We have to wake up and do these things or perish. We can easily beat Germany if we try, for our resources are better and vaster than those of that country, our shipping facilities are much superior, and our trading opportunities—with the best part of the world ready to give us practical preference and boycott the Germans—will be golden and unique. But there remains the question of American competition.

American manufacturers, with a big, rich, and well-protected home market, will prosper in any case; but our producers are specially dependent upon exports; and it is in export trade that we need to reckon up the possibilities of competition from any and every quarter. In the unprecedented demand for steel and engineering products that will spring up when peace comes—in making good the wastages and damages of war and the arrears of constructions, renewals, and repairs that are accumulating—we can afford to neglect competition, but time may bring a race for supremacy between ourselves and the Americans. It is, therefore, useful to examine broadly the comparative resources of the United States and the United Kingdom. Roughly, there was a world's export trade in iron and steel aggregating 18,000,000 tons a year before the war, valued at more than 200,000,000*l.*, besides machinery valued at another 120,000,000*l.* In round figures, Germany was exporting 6,000,000 tons of iron and steel annually; Britain, 5,000,000 tons; and America, 1,500,000 tons. After the war it is more than probable that this trade will be greater in volume and much greater in value than before the war. It is highly likely that Germany's share will be much smaller than it was before the war, which means that more will stand to be divided between the United Kingdom and the United States. By the way, these three countries—America, Germany and Britain—produce somewhere about 85 per cent. of the world's total of iron, steel and engineering products. Until the outbreak of war the United States, although possessing a productive capacity equal to that of Britain and Germany put together, never had more than a meagre share of the world's export business, as indicated by the above figures. But the opinion is strongly held in some quarters that America will henceforth undertake an export trade in some way commensurate with her capacity of production. What are the prospects? Briefly, it may be said that in abundance of natural resources and in amplitude of productive capacity, the United States is in a position to undertake something like the lion's share of the steel export business, easily beating both us and the Germans; but that in geographical compactness, in the powers of cheap production, and in shipping facilities, Britain is much better situated. The United States has the most coal and iron ore. The United Kingdom has the best assemblage, manufacturing and shipment accommodation.

In order to weigh up the position and prospects it is necessary to take a glance backwards. Between fifteen and twenty years ago we formed a very wrong idea of the United States as a trading competitor. That wrong idea has cost us dearly. For one thing, it put a blight on our own industrial development and gave Germany a chance, which she seized, to overtake and outdistance us in the steel trade. We must beware of forming wrong ideas now. Future plans must, of necessity, be based upon current ideas. At the time alluded to—the closing years of the nineteenth century and the early ones of the twentieth—Britain was exporting between 3,000,000 tons and 4,000,000 tons a year; America (U.S.) was exporting 1,000,000 tons a year; and Germany was exporting about 750,000 tons a year. There was nothing unnatural in those figures. It was only right that we, depending far more upon food imports than any other country, should export by far the most manufactures. America was a great food-producing country, not needing to export manufactures to balance food imports. Germany, too, was a great agricultural country. But since then we have allowed Germany to get ahead of us in steel exports. We shall beat Germany in the future, and we must not overlook the vital importance of maintaining the supreme position in manufactured exports.

Between fifteen and twenty years ago, whilst the resources of America—and of most other countries, for that matter—were egregiously exaggerated, not only by American, but by our own public speakers and writers, our own resources were just as absurdly underestimated. It was boldly declared that America could produce the cheapest steel; that we were rapidly becoming industrially bankrupt through the exhaustion of our coal and iron supplies; and that the United States would soon flood the world's markets with manufactured goods at prices we could not touch. It was asserted that pig-iron—the chief raw material of the steel and engineering trades—was produced nearly 20*s.* a ton cheaper in America than in Britain. It was contended that our United States rivals had only to increase their capacity sufficiently

beyond home requirements to enable them to annex the big bulk of the world's foreign trade. At least one great Englishman became so alarmed that he wrote a pamphlet declaring that our only hope of salvation lay in becoming an American colony! The effects were deplorable. Investors took alarm. Sufficient capital could not be obtained to modernise our old works, or to build new ones. Hundreds of millions of our money went abroad for investment, our industries were starved for want of capital, and the Germans rapidly overtook and eventually outdistanced us in the steel trade. But the threatened "American Invasion" did not materialise. In the fifteen years prior to the outbreak of war, though we failed to keep ahead of Germany, we managed to export nearly a sovereign's worth of iron and steel for every dollar's worth exported by the United States. The Americans vastly increased their capacity. They spent hundreds of millions on new works. Between 1900 and the outbreak of war they increased their steel works capacity, in terms of pig-iron or steel ingots, from 15,000,000 tons a year to nearly 40,000,000 tons. But they exported very little more in 1914 than they did in 1900. The bulk of the world's export business had gone to the Germans. Relatively, the Americans declined from a promising second to a bad third place in the race, whilst the Germans went rapidly ahead from third to first place, and we fell from a long lead to the second position. If we had paid less attention to the threats of American competition, to the exaggerations of the resources of other countries, and to the scares about our own supplies of raw materials, and had kept our industries advancing concurrently with the world's growing demand for manufactures, we should never have been beaten by Germany, nor need we have feared the competition of any other country. It was found, upon investigation, that we were in no danger of running short of coal or iron ore in our time, and it was seen that the Americans offered no serious competition in neutral markets, save in the case of one or two specialities, such as motor cars and typewriters. Frequently during the ten years before the war we saw between 20 per cent. and 40 per cent. of United States steel works capacity—plants capitalised at hundreds of millions of dollars—standing idle, whilst we and the Germans, between us, divided between 80 per cent. and 90 per cent. of the world's export trade. Although our combined productive capacity was less than that of the United States, we exported something like 10,000,000 tons of iron and steel a year, against America's 1,000,000 tons to 1,500,000 tons.

Now, in view of the coming new international competition, it is of prime importance to inquire why the United States, with such a huge capacity of production, has taken such a meagre share of exportation business. The reason is that our American rivals have been unable to produce and ship steel goods at competitive prices, notwithstanding all their great natural resources. And this brings us to the central and supreme fact in the issues involved. With their iron ore deposited a thousand miles from their coal mines, and their iron and steel works mostly between 400 miles and 500 miles from the seaboard, and with wages and salaries exceedingly high, the Americans have not been able to sell at a profit, or at competitive prices, outside their own protected home market. Just as the Americans rapidly increased their works capacity, so the costs of their manufacture advanced. In no other important industry did the costs of production go up so much as in the American steel trade during, say, the last fifteen years before the war, and as this question of costs is the chief point in the problem of trade it merits special attention. Fifteen years before the war Lake Superior iron ore was mined at about 1*s.* 8*d.* per ton—7½*d.* royalty, or purchase in the ground, and 1*s.* 0½*d.* for labour. In recent years the royalty has ranged up to 4*s.* 2*d.* per ton, largely as a result of the efforts of the Steel Trust to obtain a monopoly of the best ore deposits, and the labour cost has been about 2*s.* 1*d.*, partly due to the demands for higher wages and partly to deeper and more difficult mining. Again, to get the ore to the smelters—two journeys by rail and one by lake—cost 10*s.* 6*d.* per ton in the last few years before the war, against only 8*s.* 4*d.* fifteen or twenty years ago. Moreover, the iron yield has declined by one-fifth. The deeper the levels the poorer the ore, as well as the greater the expense of getting it. This involves the consumption of more coal and coke per ton of iron smelted and per ton of finished goods. And all the materials are correspondingly dearer. The net result was that before the inflation of costs by the war the cost of producing steel in the United States had increased by nearly 50 per cent. from the low levels of the end of the nineteenth century. In 1908 it was given in evidence before the Ways and Means Committee and the Inland Taxation Authorities that the average cost of producing steel in the best works in the United States was 40 per cent. higher than in 1899. Between 1908 and the outbreak of war the costs had gone still higher. In the works controlled by the Steel Trust wages alone have advanced by 46 per cent. since the war started. Mr. Gray, the chairman of the Steel Trust, is under no illusion about America's present and prospective competitive powers. He has recently expressed the opinion that the European nations, especially Britain, will emerge from the war with better industrial resources than they exercised before the war. Mr. Powell, president of the Fore River Shipbuilding Corporation, testified to this year's National Trade Convention (U.S.) that in shipbuilding American wages were 100 per cent. higher, and the output per man 12 per cent. less, than in the United Kingdom.

From time to time we hear a great deal about the superiority of American labour, but the figures given in this connection are misleading. They make no due allowance for the vastly greater expenditure on machinery and automatic appliances in America, compared with Britain. If half what we have been told so often about American efficiency and economy had been true, British goods would have been swept clean off the world's markets long ago. The simple fact is that the Americans cannot produce and ship general manufactured goods so cheaply as we can. The war, with its inflation of wages and cost of materials, coupled with abnormal taxation, may considerably modify international competitive conditions. Some high authorities hold the view that one economic effect of the war will be so to enhance our costs as to enable the United States to produce and ship at least as cheaply as ourselves and the Germans. Many American enterprises and associations are laying their plans in this belief. Much, if not everything, will depend upon ourselves. If we stick too closely to old methods and policies we may be beaten both by Americans and Germans, not to mention other nations. If our statesmen will not protect our markets and encourage enterprise more than they did before the war, if our manufacturers and shippers will not organise better, and if our workmen will not adopt a more enlightened attitude towards machinery and large-scale production, we shall certainly be beaten. But with anything like intelligent co-operation between the State and industry, and between capital and labour, we should again obtain and retain supremacy in the world's export trade. With our coal and iron supplies, manufacturing plants and shipping ports, practically side by side; with our inherent industrial skill; with our unique transport facilities; and with vast Colonies and great Allies ready to give us practical trading preferences and boycott the Germans, our opportunities will be golden. Whilst the Americans should enjoy highly prosperous trade in their own rich, protected home market, and obtain a considerable share of international business hitherto done by the Germans, we should easily take a long lead in the trade in manufactured exports, and also in shipping.

THE IGNITION TEMPERATURE OF GASEOUS MIXTURES.

The determinations of the ignition temperatures of gases, made by various investigators by various methods, have yielded widely divergent results. It could hardly be different. For the very conception of ignition temperature is indefinite, and we do not know of any generally-accepted, exact definition of that temperature. We have to distinguish between combination of gases, which is frequently luminous, and their ignition, and the demarcation line is by no means sharp. If we take the case of hydrogen and oxygen, we read in textbooks that the two pure gases, when cold, may be kept in contact with one another for years without combining to any appreciable extent, even in the light, whilst the mixture of hydrogen and chlorine, inert apparently as long as kept in the dark, will explode as soon as exposed to strong light. The probable reason of the sluggishness of the gases is that the molecules of gases have first to be dissociated into atoms before they will combine. The dissociation may be accelerated by heat, by catalytic agents, and in other ways. At 300 deg. C. hydrogen and oxygen will already combine noticeably, about 500 deg. the reaction becomes rapid, at higher temperatures it becomes instantaneous and explosive. It is this latter temperature that the experimenter wishes to determine. But it is clear that any general statement as to ignition temperature remains indefinite unless the experimenter specifies the experimental conditions as to gas pressure, proportions of the constituent gases, mode of ignition, kind of apparatus, &c. The final heat balance of the combination will be the same, whether the combination be slow or rapid. But the momentary heat effect will depend upon the rate of combination, and that heat effect and its possible consequences in causing fires and explosives constitute the practical value of the experimental determination.

What, then, is the ignition temperature? According to Professor H. B. Dixon it is that temperature to which the gases must separately be heated so as immediately to inflame when brought into contact with one another. The definition is one of the best given; it does not fit all cases, however, When a gaseous mixture is ignited by a spark, the gases are generally cold, the heating is momentary and strictly local, and it depends upon many factors whether or not the flame will be propagated. The feeble spark of an electric bell circuit may fail to produce inflammation, where a powerful spark of a circuit of considerable capacity will cause an explosion; the violent agitation of the gases produced by the strong spark, the sputtering of metallic particles from the electrodes, and other factors may help to propagate the flame. The temperatures of the sparks can hardly be measured. In either case, however, the flame will not spread, unless the mixture be of certain proportions; with both too little or too much methane in mine air, *e.g.*, an explosion will not take place. In the old Döbereiner lamp a jet of cold hydrogen gas impinging upon spongy platinum is so energetically absorbed by the spongy metal, that it catches fire. The temperature of the glowing platinum could be measured; but the observed temperature would be the consequence as well as the cause of ignition of the jet, and it would not indicate the ignition temperature. In experimental determinations of ignition temperature powerful catalysts like spongy platinum are not present, of course; but we have to confine the gases in some vessel, and the walls of the containing vessel, be it of glass or porcelain or metal, all exert a certain surface action or catalytic influence, especially when the gases are heated, and it is impossible to exclude these effects altogether.

Most of the experimental work has been done on hydrogen and, if we confine ourselves for the present to these gases and to the last thirty or forty years, mainly by four methods. Victor Meyer and his collaborators and, later Emich, plunged a bulb containing the mixture of hydrogen and oxygen into a bath kept at constant temperature; the observed ignition temperatures ranged from 518 deg. to 608 deg. C. The objections to the method are that the hot gases have been in contact with one another and with the walls before being fired, and that the gas pressure, originally of one atmosphere, would rise to about three times its value in the hot bath. In the second method a stream of the mixed gases is passed through a tube lying in the bath, which is gradually heated up; by this method the following ignition-points in degrees Centigrade were found:

Mallard and Le Chapelier, 550 deg.; Bodenstein, 653 deg. to 710 deg.; Mitscherlich, 674 deg.; V. Meyer and Freyer, 700 deg.; Gautier and Helier, 845 deg. The very high values of Gautier and Helier show the strong influence of catalysts and surface action; they packed their tube with pieces of glazed porcelain. Apart from this point the hot gases were long in contact with one another and with the hot walls while streaming. The third method, applied by Falk on the suggestion of Nernst, with special regard to compression phenomena, compressed the gases adiabatically until ignition ensued, the temperature being calculated, not observed; Falk's values ranged from 518 deg. to 569 deg. for pressure ranges from 35 atmospheres to 70 atmospheres, so that the results are not directly comparable to those of the other methods.

The fourth method of H. B. Dixon and H. F. Coward seems to offer several advantages. The apparatus consists of two concentric vertical tubes. The outer, porcelain tube is wound on its outside with platinum foil, and serves as electric furnace; the inner, glass tube reaches up to the middle of the furnace, where it ends in a small orifice; hydrogen flows through that orifice, in which a thermocouple is fixed, into the oxygen passing up the outer tube. The gases are thus at the highest temperature just at the moment when they are brought in contact with one another. The mean ignition temperature observed was 585 deg. C., and this temperature was the same for hydrogen mixed with oxygen and hydrogen mixed with air; in the latter case the oxygen would be "diluted" with about four times its volume of nitrogen. But the temperatures fluctuated widely on the upper side, *i.e.*, there was no ignition below 580 deg., but the ignition-point rose to nearly 800 deg. when the relative rate of flow, and thus the proportions of the gases, were altered by altering the size of the nozzle, and when the tube and nozzle materials were changed (various glasses, rough and glazed porcelain, quartz nozzles), and the relations were not simple, the highest temperatures being observed with the slowest rates of hydrogen flow. As the gas pressure was raised from 425 mm. to 760 mm. and 1,460 mm., the ignition temperature fell from 597 deg. to 592 deg. and 567 deg.

The same four methods were used, by Dixon and by the previously-mentioned investigators, for experimenting with other gases—carbon monoxide, methane, ethane, acetylene, ethylene, ammonia, hydrogen-sulphide. On the whole, it looks as if the fluctuations had been smaller than in the case of hydrogen-oxygen; but the range of the experiments was generally not so large either. The effect of diluents (*e.g.*, the nitrogen of the air) was sometimes very small; mixtures of hydrogen-oxygen and of hydrogen-air gave practically the same results; in the cases of the hydrogen-sulphide and methane the substitution of air for oxygen raised the ignition temperature by 100 deg. or more. Before noticing the most recent research of this kind we will allude to one other method used by V. Meyer and Münch. They passed the explosive mixtures of various gases through a capillary tube to the bottom of a small glass vessel inserted in the bulb of an air thermometer; when the mixture inflamed, the air of the bulb was displaced, and its volume was measured, the ignition temperature being thus measured.

The experiments to which we proceed were published in the Journal of the Chemical Society of London, in November, 1917, by Mr. J. Wallace McDavid, of the Nobel Research Laboratory, Ardeer. In order to avoid the influences of rates of flow and of the time factor generally, McDavid works with soap bubbles. Accepting Dixon's statement that mixtures with oxygen and with air frequently give much the same results, he mixes the gas, hydrogen or other gases or vapour with air in a 10-litre bottle, and blows, with the aid of rubber tubing, a clay pipe and a stopcock, a soap bubble of the cold mixture, when his electric igniter has been raised to the intended temperature, which is approximately known from previous experiments. His ignition temperature is thus the temperature to which the cold gaseous mixture must be heated by the application of a "hot body" so as to cause instantaneous ignition. The method is peculiar, and hardly less open to objections than others. He made use of several hot bodies. His first body was a thin-walled silicon tube wound with platinum wire, 0.025 cm. in diameter, and containing a thermocouple of platinum-rhodium. When the millivoltmeter in circuit with the couple was steady, the hot body was brought up to the bubble which was still adhering to the pipe; ignition accompanied by a slight explosion was instantaneous, when the body was sufficiently hot. In the case of Rotherham coal-gas, *e.g.*, ignition would set in when the temperature of the coil reached 800 deg. C.; at 795 deg. and less ignition would not take place. In a second set of experiments the body was a semi-cylindrical piece of iron, 1.9 cm. in diameter, 3.75 cm. long, in an axial hole of which a thermocouple was inserted; the block was heated to about 50 deg. above the intended temperature and then allowed to cool, observations being taken during the cooling period. Although this body also answered, McDavid returned to his silica tube in order to study the influences of various factors. The wall-thickness of the tube was varied between 0.055 cm. and 0.0225 cm., the internal diameter between 0.157 cm. and 0.065 cm., the length between 6 cm. and 4 cm. The thinner, smaller tubes, in which the wire was more nearly at the same temperature as the couple than in the wider tubes, gave higher ignition temperatures, the range being in the case of hydrogen 712 deg. to 758 deg. When the tube was wound with eureka wire, instead of platinum wire, the corresponding temperatures were 682 deg. and 735 deg.; this indicated a strong catalytic effect of the eureka wire, favouring combination. Finally, the hot body was formed of platinum wire wound round two notched strips of mica, 3 cm. in length and 0.3 cm. wide; the couple was between the strips. With this hot body McDavid only observed the amperemeter which measured the heating current, because his millivoltmeter in circuit with the couple did not keep steady. He ascribes this unsteadiness to a possible change in zero, variation in the room temperature, or a change in the position of the couple with regard to the coil during the experiments; he does not describe his electrical arrangements in detail, however. He found that when the bubbles were larger than the usual size, 3.7 cm. diameter, the ignition temperature was lowered, and the ignition slightly retarded. On the other hand, he considers that the cooling effect of the bubble can be neglected, because the mass of soapy water was too small, and that the influence of the size of the bubble had other reasons, namely, that a slow combustion of part of the gas (in the larger bubble) took place at the lower temperatures, and by heating the surrounding gas caused it to ignite without showing a corresponding rise in the current meter. Such an explanation should have been supported by thermocouple readings, the absence of which in these cases is all the more to be regretted. As regards neglecting the bubble moisture, one may object that a piece of damp paper visibly darkens the glowing coal, on which it is placed, before catching fire. With the thin wires and tubes of the hot bodies used, a cooling effect was not unlikely, and the retardation of the ignition seems to suggest some cooling, in fact. Mr. McDavid, however, attaches more importance to the separation of the couple from the coil, for which reason he modified his hot body as stated. The influence of the moisture in the gases he also disregards; Dixon did not find it important in several cases.

We give in the following table some of McDavid's ignition temperatures in deg. C. in the McD. column, together with a few values of others, D and C meaning Dixon and Coward, M meaning Meyer:—

	McD.	D. and C.	M.
Hydrogen-air ...	747	(already given)	
Carbon monoxide-air	931	637 to 658	650 to 730
Ethylene-air... ...	1,000	500 to 519	530 to 606
Methane-air above	1,000	556 to 700	606 to 678
Petrol (fraction 0 deg. to 80 deg.)-air ...	995	—	—
Benzene-air... ...	1,062	—	—
Ether-air	1,033	—	—

It should be noted that McDavid's figures always concern mixtures with air, whilst the other values concern mixtures with oxygen. Even remembering this the new values appear high. McDavid's method is, in a certain sense, intermediate between the electric spark methods, which are generally used for detecting the limits of explosibility of certain gas mixtures, and the other methods described. For the present it looks as if we must be satisfied with the fact that different methods will give different ignition temperatures.

RAILWAY LABOUR CONDITIONS.

RECENT developments in connection with rates of wages paid by railway companies are of wide-spread interest. Broadly stated, these have been associated with three groups of men: The engine-drivers and firemen; other operating and engineering staff; and workshop staff. Each of these groups, guided by various trade unions, has been agitating on different lines, and trade union rivalry has undoubtedly been a factor of great importance in the course of events. The engine drivers and firemen are divided in membership between the Associated Society of Locomotive Engineers and Firemen and the National Union of Railwaymen. These unions formerly had something in the nature of a working arrangement between them, but to-day relationship is extremely strained. Indeed, early this year their differences culminated in certain proceedings in the High Court. It is necessary to mention this fact, as there is ground for thinking that it had much to do with the subsequent efforts of the two unions to excel each other in pressing forward extreme demands on behalf of their members. Until April last, however, the two societies had so far not refused to be parties to an identical arrangement with the Railway Executive Committee, and they were parties to a war bonus agreement made on April 12. This granted to railwaymen embraced in the conciliation scheme a war bonus of 15*s.* per week, half that amount being payable to boys under 18 years of age. As we noted at the time [ENGINEERING, April 27, 1917] this agreement contained no provision as to any minimum period of operation, and it was not long before the unions presented fresh demands. But, meanwhile, their quarrel had developed, and they proceed to act on different lines. The Associated Society of Locomotive Engineers sent to the Railway Executive Committee, in July, a whole programme of demands, including an eight-hour day, 14*s.* a day for drivers and motormen, 10*s.* a day for firemen, and 7*s.* a day for cleaners, with a sliding-scale arrangement to provide for further increases in the cost of living.

The programme so put forward really constituted a breach of what is known as the "truce" agreement, which was entered into in October, 1914, and reaffirmed on several subsequent dates. The principle of the truce was that pre-war conditions of service should remain in operation for the period of the war. The Railway Executive Committee declined to entertain the programme, which was then put to the Board of Trade. The President pointed out that it was impossible to give effect to an eight-hour day during the war, but he gave a pledge that the Government would continue the present control of railways for a time after the cessation of hostilities, so that there would be an opportunity afforded within one month to bring forward a request for a shorter working day while the railways were under control, and that any reasonable request for a shorter working day would have the immediate and sympathetic consideration of the Government.

This promise did not satisfy the men. A strike was threatened, and was only prevented by a proclamation applying Part I of the Munitions of War Act, 1915, to the dispute: the strike was not called, and the dispute was referred to the Committee on Production. The hearing occupied two days, numerous witnesses being called, and practically the whole of the men's service conditions were referred to. The committee, however, pointed out that they were only able to consider claims for additional wages to meet increased cost of living due to the war, and that their usual practice had been to grant a flat advance of wages, while not interfering with the relative rates of pay of the various classes of workpeople as they existed prior to the war. The committee's award was to give an advance of 5*s.* per week on the war wages of engine drivers, firemen, motormen and cleaners of 18 years of age and upwards, and 2*s.* 6*d.* to boys,

making the full amount of the war bonus up to 20*s.* per week to adults and 10*s.* to boys.

Meanwhile the National Union of Railwaymen had been busy. In August they submitted to the Railway Executive Committee a request that the war bonus then being paid should be converted into war wages, thereby reckoning in the calculation of payment for overtime and Sunday duty. This application was granted, all employees in grades engaged in the manipulation of traffic being granted the following war wages:—

	Per Week. s. d.
Male employees, 18 years of age and upwards	15 0
Boys under 18 years of age	7 6
Women employees, 18 years of age and upwards	5 6
Girls under 18 years of age	3 9

The agreement was to remain in operation during the war, provided that if at any time after the expiration of three months from August 8 there was a substantial change in the abnormal conditions prevailing in August, either side might demand a revision.

During the period when the Associated Society of Locomotive Engineers and Firemen were threatening to call out their members to force the demand for an eight-hours' day the National Union of Railwaymen made considerable display of their respect for agreements, but—despite the fact that the "abnormal conditions," as demonstrated by Board of Trade cost of living statistics, had not changed—the union lost no time in demanding a revision of the August agreement. At a meeting with the Railway Executive Committee an increase of 10*s.* per week in the war wages was demanded. After some negotiation, and practically at the same time as the award of 5*s.* was made to enginemen, the National Union of Railwaymen came to a provisional agreement with the Railway Executive for the same amount. Apparently, however, the representatives of the union had no power to settle, and a conference of the members rejected the offer of 5*s.* Negotiations were broken off, the union approached the Government, strike resolutions were passed in various parts of the country, and in the Liverpool area the men resorted to a "slow" strike—that most dishonest of all labour weapons. After a somewhat excited few days negotiations were reopened with the Railway Executive Committee last week, and on November 29 an agreement was made. To the general surprise of all large employers of labour, the war wages now granted to railwaymen exceed those paid under even the most recent awards of the Committee on Production, an increase of 6*s.* per week being granted to male employees of 18 years of age, making the total war wages to men 21*s.* per week, half that amount being payable to boys. The agreement is supplemental to previous agreements entered into by the Railway Executive Committee and the National Union of Railwaymen and other trade unions, and is to remain in operation without amendment until March 31, 1918, and shall then be subject to revision only if there shall have been a considerable alteration in the cost of living as shown by the Board of Trade returns. In the light of the agricultural labourers' recently-fixed minimum wage of 25*s.* per week, it is difficult to understand how a war wage of 21*s.* plus 20*s.* standard wage can be justified in the case of, say, permanent-way men in country districts, who are largely of the agricultural labourer class. We regard the position as distinctly unsatisfactory from the shareholders' point of view, and we think it high time that the Railway Executive Committee—who in this matter represent the Government—made known to the public what the service conditions of railwaymen are, in order that further demands may not be bolstered up by the plea that, as a class railwaymen are inadequately remunerated.

So far as employees in railway workshops are concerned there appear to have been several different forms of negotiation. When the first war bonus was granted to railwaymen in February, 1915, it was very generally extended to workshop employees. With the establishment of the Committee on Production, however, several of the large companies were parties to proceedings before that body, and awards were given in a number of instances under which the men received advances of wages amounting to 4*s.* per week, with a 10 per cent. increase of piece-work prices. Subsequently the Railway Shops Organisation Committee of Craft Unions and the National Union of Railwaymen negotiated with the Railway Executive Committee, and in August last a comprehensive agreement was entered into, the essence of which was that the general increase in rates of wages, piece-work prices or bonus granted since August 4, 1914, as the result of any awards given by the Committee on Production or by negotiations with representatives of the railway companies and the Railway Executive Committee were cancelled and the following increases were substituted:—

To male employees of 18 years of age and upwards employed on time-work	15*s.* per week war wages.
To male employees of 18 years of age and upwards employed on piece-work	8*s.* per week. war wages, 7*s.* per week on time rates or 17½ per cent. increase on piece-work prices.

This agreement does not appear to have given any large measure of satisfaction, and it is possible that to some extent trade union rivalry has also been a factor in causing discontent. Not only has there been a display of feeling in certain centres between members of craft unions, such as the Amalgamated Society of Engineers and the Boilermakers Society, but the growing influence in railway workshops of the National Union of Railwaymen has been resented by the craft unions. Organised as an industrial union, and admitting to membership any employee of a railway company, no matter in what grade, the National Union of Railwaymen has secured a considerable membership in some places, and there have been local strikes in which this has probably been the principal cause, but a still more important feature is that the craft unions generally seem to be desirous of forcing the railway companies to pay district rates of wages and adopt trade union conditions. These efforts have met with little success. The Great Eastern Railway have successfully resisted a claim that such rates should be paid, and within the past few weeks the Committee on Production has dealt with an application by the Railway Shops Organisation Committee of Craft Unions, Horwich and Newton Heath Joint Committee, on behalf of all craftsmen employed by the Lancashire and Yorkshire Railway, except boilermakers, for the payment of the district rates of wages and observance of the same working conditions as apply in private contract shops to the same grades of tradesmen. In their award the Committee on Production say that the men in question have received during the war advances by way of war bonus amounting to 15*s.* per week above their pre-war rates and, in conformity with an agreement made between the Railway Executive Committee and representatives of the Railway Shops Organisation Committee of Craft Unions in August, 1917, the war bonus was converted into a war wage advance as from August 1, 1917, making the advance on pre-war rates the same as the advances then obtaining for the general engineering trade. As in the case of a number of other railway companies, it was not the practice of the Lancashire and Yorkshire Railway prior to the war to agree to pay district rates of wages to members of the unions employed in the shops, but, in fact, some of the rates paid by the company are equal to or more than the district rates, while other rates paid by the company are less than the district rates. The company contended that their shops were not competitive commercial establishments and the conditions of employment, which include certain privileges, were not similar to those in ordinary private engineering establishments. The decision of the Committee on Production was that the application could not be granted in present circumstances, the finding being without prejudice to the position of the parties in regard to the matter after the war.

There is evidence that these decisions have not been favourably received by the men. On the other hand it is quite clear that, if railway workshop employees are to be paid district rates of wages and to be given district conditions, they cannot expect to also secure continuity of employment in periods of depression nor to retain other privileges incidental to railway employment, while so far as the railway companies are concerned if they adopt district conditions it follows that they must be associated with other engineering employers in negotiating those conditions. What the future developments are likely to be is by no means clear, although a considerable measure of success seems to have been secured by the Great Central Company in adopting what has become known as the "railway district rate." Whatever may be the outlook, however, it seems unlikely that an agreement such as that entered into in August last between the Railway Executive Committee and the Railway Shops Organisation Committee of Craft Unions and the National Union of Railwaymen will be continued after its period of operation, especially in view of the experience of several companies, notably the London and South Western, Great Eastern and Great Western. This experience is that, whilst accepting all the concessions obtainable by what may be termed "central" or "national" negotiation, employees at various large centres or sections of them have struck to obtain further advances by local effort.

In this respect particular reference may be made to the case of the Great Western Railway. A strike of boilermakers employed at Swindon took place in October and the dispute was ultimately referred to arbitration. Despite the fact that the Boilermakers' Society was a party to the agreement made by the Railway Shops Organisation Committee of Craft Unions, further advances of wages were awarded, and conditions established which were at variance with the terms of the August, 1917, agreement. Incidently also the Court awarded that a Joint Committee of three representatives of the company and three of the chargemen or men concerned should prepare an agreed list of rates for ordinary piece-work items, including plating, riveting, drilling and caulking work, as well as all items of work now carried out by squads; piece-work rates for special jobs to be settled from time to time by agreement. Failing agreement, the prices to be settled in all cases by an arbitrator to be mutually agreed on.

As we have stated, the general experience is such as not to encourage the hope that any new agreement can be entered into by the Railway Executive Committee with the Railway Shops Organisation Committee of Craft Unions unless that body is able to guarantee its acceptance by the men in the form and spirit in which it might be drawn. Based on the experience of the agreement between the Engineering Employers' Federation

Summary of War Bonus and War Wage Arrangements.

—	February, 1915. Per Week.	June, 1915. Per Week.	October, 1915. Per Week.	September, 1916. Per Week.	November, 1916. Per Week.	April, 1917. Per Week.	August, 1917. Per Week.	December 1917. Per Week.
	War Bonus.						War Wages.	
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Male employees, 18 years of age and over, at 30*s.* per week or more	2 0	2 0	5 0	10 0	10 0	15 0	15 0	21 0
Male employees, 18 years of age and over, at less than 30*s.* per week	3 0	3 0						
Boys under 18 years of age	—	1 6	2 6	5 0	5 0	7 6	7 6	10 6
Female employees, 18 years of age and over	—	—	—	—	3 0	5 6	5 6	8 6
Female employees, under 18 years of age	—	—	—	—	1 6	2 9	2 9	4 3

and the craft unions we are inclined to the view that the railway companies would be well advised to allow their locomotive workshop conditions to be settled by the Committee on Production.

For convenience of reference we give on the opposite page a summary of the war bonus and war-wage arrangements which have been made in respect of railway companies' employees who are embraced in the Conciliation Scheme, viz., those engaged in the manipulation of traffic. The conditions provided by these agreements, with minor modifications, may be said to have been extended to practically all grades of the staff.

In conclusion, it is desirable to direct attention to the very serious fact that the present cost of war concessions to railway employees, which was officially stated to be 28,000,000*l.* when the 15*s.* war wages applied, now is not less than 36,000,000*l.* per annum, or more than the amount paid as dividends on the ordinary, preferred and guaranteed stocks of the railway companies.

DR. JOHNSON ON AERONAUTICS.

By W. H. THORPE.

AT a time when the art of aviation attracts so much attention, it may be of interest to recall that Dr. Johnson was perhaps the first to state with accuracy the principle involved in any successful effort with "heavier-than-air" machines. How it happened that he, who had but a casual acquaintance with the science of his time, directed his attention to this matter, it is now impossible to say. Many attempts had been made by enthusiasts, to solve the problem, during the Middle Ages. Leonardo da Vinci and Roger Bacon, later Borelli and Hooke, had studied the subject and made proposals, and there had been consideration of "lighter-than-air" methods, but nothing seems to have been done immediately before Dr. Johnson's speculations, which may be thought to account for his interest in the question.

In 1759, to raise money for payment of charges consequent upon the death of his mother, he wrote "Rasselas, Prince of Abyssinia," a remarkable book telling of a quest for happiness. The story relates that before starting on his travels with this object, the prince, amongst other devices to relieve *ennui*, had consorted with men of learning and skilled exponents of various arts; amongst these, a mechanical genius, referred to as the "artist," who, to provide amusement for his patron, suggested an attempt at flight, and in discussing the matter says: "He that can swim needs not despair to fly; to swim is to fly in a grosser fluid, and to fly is to swim in a subtler." Then follows this enunciation of principles: "We are only to proportion our power of resistance to the different density of matter through which we are to pass. You will be necessarily upborne by the air, if you can renew any impulse upon it faster than the air can recede from the pressure." This is a remarkable statement having regard to the state of knowledge at the time—159 years since. It correctly defines the principle underlying "heavier-than-air" aviation.

Dr. Johnson's was a mind extraordinarily active, and not to be deterred from addressing himself to a strange subject by its strangeness merely, so that no great surprise need be felt that he should consider this, but only that he should have made so illuminating a pronouncement with respect to a branch of study alien to his usual pursuits. By a Newton, or a Cayley, it might, most probably would, have been stated with more of mathematical precision and effect, but not more truly. It is not improbable that Johnson, mingling with the intellectuals of his time, got the idea, expressed so well, from one of these, but there is no evidence of this, and we need not question but that his naturally vigorous intellect was well able to go straight to the root of such a matter, even though it might be on ground unfamiliar to him. On the other hand, he may not himself have fully realised the truth of the statement, a supposition countenanced by other theories advanced by the "artist" of a much less acceptable nature.

It is of interest to note that the prince is described as having given his consent to the experiment, the mechanic stipulating that his invention should be kept secret for reasons which must appeal to us to-day. He says: "If men were all virtuous, I should with great alacrity teach them all to fly. But what would be the security of the good, if the bad could at pleasure invade them from the sky? Against an army sailing through the clouds, neither walls, nor mountains, nor seas, could afford any security. A flight of norther savages might hover in the wind, and light at once with irresistible violence upon the capital of a fruitful region that was rolling under them."

The narrative may be read with advantage, but it may be said that the "artist," notwithstanding his grasp of the fundamental principle, made the attempt with wings fitted to his own shoulders—and failed.

Later in life, Johnson appears to have been attracted by the attempts of the balloonists. The Montgolfier brothers were experimenting in 1783, and on September 29, 1784, the doctor wrote to a friend that he had received three letters in one day about "the air balloon," probably referring to the ascent of Luanardi (secretary to the Neapolitan Ambassador) in London, on the 15th of the same month.

In this letter the writer seems rather to slight the effort, remarking that lack of directing power would render balloons useless for transport, and that unless able to rise above the highest mountains (which had not been done), useless as a means of extending knowledge of the upper air.

In October of the same year, with reference it is to be supposed to some mishap, the doctor wrote: "The fate of the balloon I do not much lament, to make new balloons is but to repeat the jest again . . . The first experiment, however, was bold, and deserved applause and reward. But since it has been performed, and its result is known, I had rather now find a medicine that can cure an asthma."

LITERATURE.

Industrial and Manufacturing Chemistry. Part II. *Inorganic.* By Dr. GEOFFREY MARTIN, Ph.D., D.Sc., F.I.C. Two volumes. London: Crosby Lockwood and Son, 1917. [Price of each volume 25*s.* net.]

THE two volumes on Inorganic Industrial Chemistry, a continuation of Dr. Martin's treatise on Organic Industrial Chemistry, cover practically the whole domain of industrial inorganic chemistry excepting explosives and metallurgy. The exclusion of metallurgy is extended to metal-plating and galvanic processes, and to compounds of the metals of the metallurgist; but the rare metals, including uranium, and especially the metals of importance for the glow-lamp industry, are considered. Fuels, furnaces, coke ovens and producer gas are also dealt with, whilst coal gas is not. The matter is treated by different authors in 89 sections of very unequal length, which fill two large octavo volumes, each of nearly 500 pages, counting the considerable number of empty pages between the many sections. Prominent among the authors are the editor and Mr. A. R. Searle, of Sheffield. Dr. Martin signs the sections on coke ovens; refrigerating machinery; sulphur, sulphuric acid and other sulphur compounds; the salt industry, soda, chlorine and the halogens, hydrochloric acid, alkalis, chlorates, bleach; cyanides; disinfectants and antiseptics; aluminium compounds; lutes and cements, zeolites, artificial gems, and artificial teeth—the last a very short section of only half a page's length, sufficient for the purpose. Mr. Searle has contributed the sections on solid and liquid fuels, furnaces, pyrometry; and the large group of sections on clay, glass, ceramics and refractory materials. The whole group on the rare earths and metals, of interest rather to the illuminating engineer than to the chemist, has been compiled by Mr. Sydney J. Johnstone. The late Major J. Louis Foucar has written the section on briquettes and, together with the editor, the sections on sulphuric acid. Other authors will be named in due course.

Some of the articles appeared familiar to us. Looking into the matter we find that the twelve chapters on Industrial Gases and the Liquefaction of Gases of one of Dr. Martin's Manuals of Technology, the one which we noticed in our issue of October 13, 1916, have been bodily transferred, word by word, page by page, with misprints and without alterations, into Vol. I of his new publication. The only change is that what was called a chapter is now styled a section. In the same way all the chapters of Vol. IV of the Manuals, on Chlorine and Chlorine Products; of Vol. V, on Sulphuric Acid and Sulphur Products; and of Vol. VI, on the Salt Industry, have been incorporated in the new publication, to which Dr. Martin has further added—to supplement his section on disinfectants and antiseptics—the chapter on organic compounds of this class from his Organic Industrial Chemistry. This latter fact is pointed out in the preface. But neither the preface nor the text make any mention whatever of the Manuals; otherwise references to Dr. Martin's work abound.

The reader is favourably impressed with the concise matter-of-fact style of almost all the articles and the manifest practical knowledge and fairness of the authors, who go right into the matter and touch upon historical points only when essential for the development of an industry. He will also be pleased with the absence of overlapping; the formidable number of 89 sections rather prepares him for some such result. The only case which we have noticed, however, is that a diagram by means of which Dr. Martin explains the production of nitrogen by passing air over heated copper is reproduced in the section on cyanamide. The preface, the language of which contrasts somewhat with that of the subject-matter, claims that special pains have been taken to secure the most recent available data, that much of the information is published in book form for the first time, that many descriptions of new processes and modern plants have been supplied by the courtesy of chemists and leading firms, that the patent literature has been utilised to the fullest extent, and that the volumes afford, so far as is ascertainable in view of secret processes employed, thoroughly up-to-date information. We cannot say that these facts would have occurred to us, and while fully welcoming the patent lists, we rather regret to find descriptions of electrolytic alkali and bleach apparatus, *e.g.*, after patent specifications, when descriptions of the actual apparatus were available. We are not disregarding the stress of the times we live in, nor the manufacturer's love of secrecy. But the book was published in 1917, the war broke out in 1914, and the statistics—which are not a strong point of the book, as, indeed, they could scarcely be—are hardly carried to 1912 in the best cases, while the literature references generally close with 1913. There are, however, noteworthy exceptions in Dr. Alexander S. Russell's section on Radioactive Substances, Mr. H. D. K. Drew's section on Electric Furnace Products, and in some others. From Mr. Searle's few words on chemical glass and stoneware, and from the absence of any reference to chemical porcelain, one would hardly conclude that these specialities were of any significance, and that the British chemical industry was at the beginning of the war as much troubled by the want of these articles as by the dearth of certain products and raw materials. In his section on the Technology of Water, comprising sewage, Dr. H. Hodgson does not say a word on activated sludge and very little on aeration processes, which have been prominent for a good many years, and his remark on the treatment of potable water by ultraviolet rays and on the work of Henri, Helbronner (not Hellbranner) and Recklinghausen, "resumed two years ago," also suggests that this contribution was practically completed before the war.

Somewhat unsatisfactory are the occasional references "see, however, . . ." qualifying a statement without sufficiently indicating in which sense; and, further, the long strings of dozens of patents without names to be found in some sections. Long lists of the "chief patents" are given in some sections, with name and number, but without any explanatory notes, and they have their value. The reader, having noticed misprints, may feel a little distrustful as to the nameless patent, however; the search for a patent with a wrong number is hopeless, when the reader merely knows that the patent concerns catalysis or incandescence lamps in some way

But the distrust would be unjustified. We have looked up a good many patents; the numbers all proved correct, except in one case, and there the name was given; the British patent No. 4820 of 1901 concerns an electric switch by Mr. W. Duddell and not the cyanide process of Sir George Beilby. The misprints to which we just alluded are mostly of a harmless nature: Brinn's (instead of Brin's) oxygen process, C. H. Desche (Desch) on cement testing, Merves (Mewes) on liquefaction of gases, Montlaux (Montlaur) on electrolytic chlorates, Taufmann (Kaufmann ?) on radioactive rain, will not seriously embarrass the reader, nor will another peculiar kind of mistake. Somebody seems to have remembered that the final s of names often indicates the possessive case and should be separated by an apostrophe from the name; thus we find: Siemen's furnaces, Kopper and Kopper's (instead of Koppers') coke oven and ammonia recovery, Bett's (Betts', hydrofluoric acid), Gibb's (Gibbs, electrolysis, &c.); and this not merely in a few instances, but persistently and in bold type, under diagrams and in the subject-matter. The name of Hjort, of Messrs. Lassen and Hjort, is either spelt Hjert or H. Jort. The mistakes are not serious, but annoying, and attention might have been drawn to them when they reappear in a second publication.

The engineer would hardly consult this book on fuels, furnaces and briquettes; what he might look for in these sections is information on the chemical control of combustion, and as to that Mr. Searle offers him four lines on an Ados or other "CO_2mbustion" (*sic*!) meter—the peculiar abbreviation has probably been overlooked—and there is no reference to a book on the subject. Mr. Searle condenses a great deal of useful information into the one and a half pages on peat. There is one mistake, we believe. He speaks of Engelhardt's attempts at getting the slimy peat water, which will not filter, ready for the press by treating the peat with superheated water under pressure, whilst Gercke later used steam for the same purpose; both the attempts failed, chiefly because proper circulation of the peat through the boilers could not be maintained, we believe. The former name should evidently be Ekenberg, and it might have been mentioned that considerable work was done in Ireland, where the Ekenberg process was combined with ammonia recovery from peat furnaces, and that a large plant on the Frank-Caro system was established in 1910 at Schweger Moor, near Osnabrück. This plant (Mond gas generation with ammonia recovery) was no longer working when the war broke out, whilst the power station near Aurich, which burns meadow peat—not peat from undrained moors—for generating electricity by means of steam turbines, was doing well, as far as we are aware. We readily admit, on the other hand, that what is given is to the point, and that applies to most of the other sections, and will be borne in mind by our readers, we hope. We also agree with Mr. Searle that much of the literature on pyrometry is obsolete; but in his very appropriate reference to trade catalogues he does not himself carry us further than 1912, however. Dr. Martin's section on Coke Ovens is poor. If it was worth while to give the production of coke-oven gas in the Ruhr district for 1909, something might have been said on the 1,000,000 cub. ft. of gas now piped per day from the Middleton ovens to Leeds. Mr. H. Stanley Redgrove contributes a very readable section on Producer Gas, Water and Air Gas; he might have alluded to the term "oherry" (fuse of peroxide) in his section on Alumino-Thermics.

Dr. H. H. Hodgson had a hard task in dealing with the Technology of Water in 37 pages. He might have gained a little space by giving less prominence to one firm. Effluents and sewage receive insufficient allowance; the ninth final report of the Royal Commission on the Disposal of Liquid Wastes from Manufacturing Processes, of February, 1915, had evidently not been seen by the author. Australians may be surprised to learn that the drinking water from artesian wells requires no further purification. Artificial Mineral Waters form a special section by Mr. C. Ainsworth Mitchell. Mr. Frank Milsom's section on the Stassfurt Industry is rather short, though it deals with a local special industry. He is also author of the section on the Salts of Potassium, Barium, Strontium and on Boron Compounds, in which he might have referred to boron itself and recent work on borides. Barium, it is stated, "occurs next to strontium," and "strontianite is subjected to the action of superheated steam and then ignited," and the borax statistics end with 1902. Dr. Martin carries his statistics on Bromine in Ohio to 1902, on Iodine to 1907, and these latter figures concern only Germany, whilst we have some figures on sodium nitrate from Chile and Peru up to 1912.

Apart from the section on the Ammonia-Soda process, with which Mr. Stanley Smith, of the Ammonia-Soda Company, deals very satisfactorily, and a brief section on Gypsum by Mr. James Shelton, the whole domain of the Alkalis, Soda, Sodium Carbonate and Nitrate, Nitric Acid, Ammonia and Ammonium Salts, Chlorine and the other halogens, Hydrochloric Acid, &c., Cyanides and Cyanamide, has been taken in hand by Dr. Martin, who is, as we said already, also joint author with the late Mr. Foucar, assistant manager to the Beckton Gas Works, of the sections on Sulphur and Sulphuric Acid. The sections on the Wealdon and Deacon Processes, and on Bromine, refer to fuller accounts on "Halogens and their Allies," by Dr. Martin and Mr. E. Dancaster, in Vol. VII of "Modern Inorganic Chemistry" (1915), edited by Dr. N. Friend. The articles profit, no doubt, by the uniform treatment of the allied subjects of natural groups like that of the alkalis and acids, but the task is very heavy. That applies likewise to the large group on clay and pottery, earthenware, stoneware and sanitary ware, porcelain and glass, refractory materials, enamels and abrasives, with which Mr. Searle deals in the second volume. Frequently one would like further and more recent information. Of the Tentelew-Eschelmann process (catalytic sulphuric acid) we have nothing but the name; no statement that it is worked on a large scale in Russia. The reader would hardly gather, from the remarks on stoneware and culinary ware, that stoneware coils, taps, fans, &c., of large dimensions have long since become indispensable to the chemical manufacturer; and, further, that glass mirrors can be plated with metals other than mercury and silver. The only electrolytic silver-plating process referred to—altogether the only metal-plating process mentioned, the French patent 444,710, name and date, Declere and others, 1912, not given—scarcely stands out sufficiently from others to justify its being singled for notice. But charges of sins of omission could be met by the plea of space exigencies, of course.

The last group of articles on which we will comment is that by Mr. Sydney H. Johnstone on the Thorium and Cerium and Incandescent Lamp Industries, and on the rare metals Titanium, Zirconium, Tantalum, Niobium, Tungsten and Vanadium. There is much good in these sections as well, though they do not comprise metallurgy, and the author may fight his own battle if he should be assailed for speaking of niobium (instead of columbium), a name which British chemists repudiate. But Mr. Johnstone seems to be wrong on one point. He distinguishes two classes of processes for producing tungsten filaments: processes yielding a finished filament of tungsten alloyed with some other metal; and processes during which an alloy is produced at some stage, but which leave a filament of tungsten alone. That mixtures of tungsten with thoria and other compounds of the rare earths are used is pointed out; but it is not said that thoria itself was added by Kuzel and others to serve as conductor of the second class, *i.e.*, as a substance conducting the current when hot, and not with the object of being reduced to metal.

In fairness to the authors of sections not so far noticed on this occasion, nor last year in our review of "Industrial Gases," we supplement our list of the contents of these two volumes. There remain: Surface Combustion, by Mr. E. Jobling; Peroxides and Peracids, by Dr. G. W. Clough; Calcareous Cements, by Mr. E. A. Dancaster; Sorel Cements, *i.e.*, cements consisting of a paste of calcined magnesia and magnesium chloride, Artificial Stones, Sodium Silicate and Water Glass, Lime Bricks, by Mr. James Shelton; Asbestos and Mica, by Mr. F. W. Penny; Phosphorus and Matches, by Mr. C. Ainsworth Mitchell, and Electric Furnace Products, by Mr. H. O. K. Drew. In this last section we rather miss reference to boron nitride, and to borides and silicides, though we admit that these latter products are hardly industrial so far. Dr. Martin alludes to unsuccessful attempts of utilising the nitrides of boron and titanium in the section on Ammonia; these nitrides have found some ceramical application, however.

There is a good subject-matter index, comprising names coupled with processes or apparatus, at the end of the second volume, but no special name index. Glancing through these volumes one would often welcome more detailed references; quotations of the dateless, possibly antiquated, second report of some commission, and of book titles and encyclopædia articles without dates are unsatisfactory. Some general sections on solution and solvent, evaporation and analysis might perhaps have been added, and the reader would gain a better impression of the comprehensiveness of the treatment, if the names of some firm or other were less conspicuous in the illustrations and subject-matter of certain sections.

INDUSTRIAL NOTES.

The Parliamentary Committee of the Trade Union Congress in presenting their report to the Blackpool Congress, dealt at some length with the interim report on Joint Standing Industrial Councils, known as the Whitley Report, the following sentence indicating the view entertained towards the recommendations by the Parliamentary Committee:—

"After giving very full consideration to the interim report on Joint Standing Industrial Councils, the Parliamentary Committee expressed their agreement with the general terms of the recommendations embodied therein, which appeared to suggest that all machinery set up to deal with industrial differences between employers' associations and trade unions should be established on a voluntary basis and be secured by mutual agreement."

This information was conveyed to the trade unions by special circular in July last.

As a result of an interesting and very full discussion at Congress, the subject was referred back to the committee, in order that further consideration might be given to the recommendations and at a meeting of the Parliamentary Committee held on December 13, the opinion expressed in July last was re-affirmed.

The Parliamentary Committee are satisfied that the Whitley Report contains proposals of real value, which are capable of being adapted to the varying conditions of the different trades, provided always that they are accepted and acted upon by both sides in a broad and friendly spirit.

The General Federation of Trade Unions has addressed to the workmen affiliated to the "Confédération Generale du Travail," a circular letter of which the following are abstracts:—

"In 1914 Germany plunged the whole world into war. No sophistries concerning pre-war politics can ever obscure this fact. It is so obvious as not to need arguing. Britain's entry into the conflict was determined by Germany's action, and not by warlike ambitions. Hating war, appreciating fully the misery and wastefulness of war, and frequently attending international conferences to promote peaceful relationships between the peoples of different countries, the British trade-union movement was yet compelled to take its stand at the back of any British Government which stood to maintain treaty obligations to Belgium and moral obligations to France. . . .

"Britain occupies, and has occupied from the beginning, the position of the citizen who seeks to prevent a thief stealing the goods of the citizen's neighbour. It is absurd to suggest that Britain stands in the way of peace. . . . As the responsibility for the commencement of the war rests with Germany, so with her rests the responsibility for the continuance of war. . . . Germany did, indeed, in September, permit a neutral power to indicate her desire for peace, but she has never replied to Britain's expressed willingness to consider and to place before the Entente Powers any terms she cared to specify. Germany has sought to create prejudice against Britain by constantly reiterated, but vaguely expressed, declarations concerning the freedom of the seas. In the days that preceded Germany's declaration of war upon France, the maritime traffic of the whole world crossed the seas without let or hindrance, and the ports of Great Britain were free to the ships of all nations. So great was this freedom that it led to internal controversy; many thousands in Britain holding that the freedom

accorded by Britain to the world's ships and merchandise was prejudicially affecting the interests of Britons themselves. Germany, during the last three years, has shown by her practices how small is her respect for the formula she circulates. . . . In December, 1915, the General Federation stated that if Germany seriously wished to discuss terms of peace that provided restoration, reparation, and security, peace need not be delayed one single day. Germany has not yet accepted this intimation. She is under no compulsion to fight; her existence is not in danger; no one, at least no one in Britain, desires or expects that she shall be utterly destroyed; no one would even question her right to maintain a military autocracy, to contribute her money and her sons towards the maintenance of militarism, if these were necessary to her own existence, and were used only inside her own borders for the defence of her own interests. The only thing that Britain, with the rest of the world, seeks to destroy is the Prussian autocracy's military power for external offensives. This is what Britain stands for: the right of the invaded territories to restoration and liberty. . . . . It is inconceivable that the democracies of America, France, and Britain, themselves enjoying freedom, and the democracy of Russia which is struggling towards freedom, should accept, while life remains, the terms that are inevitable if German autocracy succeeds. It is for these reasons, amongst others, that the General Federation of Trade Unions urges upon the democracies of the Allied Powers the need for concentration upon efforts to destroy, not Germany, but the militarism which holds even German democracy in subjection. If there was any probability of securing peace by immediate negotiation, the General Federation would not hesitate to advise negotiations. Its whole history is one of efforts to promote industrial peace by negotiation, but in the absence of any definite communication from the Governments of the Central Powers, and in the presence of the impotence of the democracies of the Central Powers, the free democracies must continue the struggle until their present and future security is assured.

The terms of the proposed agreement between the Engineering Employers' Federation and several trade unions on the shop stewards question were issued last Saturday, the 22nd inst.

The unions who have signed the agreement are the following: Steam Engine Makers' Society; United Machine Workers' Association; Society of Amalgamated Toolmakers, Engineers and Machinists; United Kingdom Society of Amalgamated Smiths and Strikers; Electrical Trades Union; National Society of Amalgamated Brassworkers and Metal Mechanics; United Journeymen Brassfounders', Fitters', Turners' and Finishers' and Coppersmiths' Association of Great Britain and Ireland; Associated Blacksmiths' and Iron Workers' Society of Great Britain and Ireland; Amalgamated Society of Coremakers of Great Britain and Ireland; Workers' Union; National Union of General Workers; National Amalgamated Union of Labour; whilst the Amalgamated Society of Engineers, the Scientific Instrument Makers' Trade Society, and the National Amalgamated Union of Enginemen, Firemen, Mechanics, Motormen and Electric Workers, which are parties to the existing provisions for avoiding disputes, have not yet signed it.

The agreement reads as follows:—

With a view to amplifying the provisions for avoiding disputes it is agreed:

1. The workmen who are members of the above-named trade unions employed in a federated establishment, may appoint representatives from their own number to act on their behalf in accordance with the terms of this agreement.

2. The representatives shall be known as shop stewards.

3. The method of election of shop stewards shall be determined by the trade unions concerned, and each trade union, party to this agreement, may appoint shop stewards.

4. The names of the shop stewards and the shop or portion of a shop in which they are employed and the trade union to which they belong shall be intimated officially by the trade union concerned to the management on election.

5. Shop stewards shall be subject to the control of the trade unions, and shall act in accordance with the rules and regulations of the trade unions and agreements with employers so far as these affect the relation between employers and workpeople.

6. In connection with this agreement shop stewards shall be afforded facilities to deal with questions raised in the shop or portion of a shop in which they are employed. In the course of dealing with these questions they may, with the previous consent of the management (such consent not to be unreasonably withheld) visit any other shop or portion of a shop in the establishment. In all other respects they shall conform to the same working conditions as their fellow-workmen.

7. Employers and shop stewards shall not be entitled to enter into any agreement inconsistent with agreements between the Engineering Employers' Federation or local associations and the trade unions.

8. The functions of shop stewards so far as they are concerned with the avoidance of disputes shall be exercised in accordance with the following procedure: (*a*) A workman or workmen desiring to raise any question in which he or they are directly concerned shall in the first instance discuss the same with his or their foreman. (*b*) Failing settlement, the question shall, if desired, be taken up with the management by the appropriate shop steward and one of the workmen directly concerned. (*c*) If no settlement is arrived at the question may, at the request of either party, be further considered at a meeting to be arranged between the management and the appropriate shop steward together with a deputation of the workmen directly concerned. At this meeting the organising district delegate may be present, in which event a representative of the Employers' Association shall also be present. (*c*) The question may thereafter be referred for further consideration in terms of the provisions for avoiding disputes. (*e*) No stoppage of work shall take place until the question has been fully dealt with in accordance with this agreement and with the provisions for avoiding disputes.

9. In the event of a question arising which affects more than one branch of trade or more than one department of the works the negotiation thereon shall be conducted by the management with the shop stewards concerned. Should the number of shop stewards concerned exceed seven, a deputation shall be appointed by them not exceeding seven for the purpose of the particular negotiation.

10. Negotiations under this agreement may be instituted either by the management or by the workmen concerned.

11. The recognition of shop stewards is accorded in order that a further safeguard may be provided against disputes arising between the employers and their workpeople.

12. Any questions which may arise out of the operation of this agreement shall be brought before the executive of the trade union concerned or the federation as the case may be.

There is now great urgency for certain classes of additional labour in the Clyde shipyards, says *The Glasgow Herald*. In particular, men are required as helpers to the workmen of the principal trades. The difficulty has been relieved to some extent by the introduction of women into the lighter work, but in the case of shipyard work there are many occupations of a heavy and hazardous nature unsuited to female labour. The time has therefore arrived when it is necessary to introduce more male labour when no further extension of dilution by women is practicable, but a new difficulty is being experienced owing to the shortage of lodging accommodation for men coming into the district. As it is now expected that men can be sent from other parts of the country to relieve the shortage on the Clyde, the Admiralty are faced with the question of lodging accommodation, and that department is taking up the matter of hostel accommodation, and propose to set up receiving depots, one in Glasgow for the upper reaches and one in Greenock for the lower reaches. These depots are to serve the purpose of providing men with accommodation immediately upon their arrival, and for such time as they require to obtain for themselves lodgings suitable to their tastes. It is necessary, however, in addition to this, to have a list of available lodgings, so that such men can, without too much loss of time, make their selection without the difficulties experienced at present in searching for lodging accommodation. On behalf of the Admiralty, the *Herald* is asked to make public this appeal for lodging accommodation in the whole of the Clyde district, and it is requested that information as to the availability of same should be sent to the District Director, Shipyard Labour (Scotland), 250, St. Vincent-street, Glasgow.

AEROPLANE MAIL SERVICE IN ITALY.—For some months a fairly regular aerial mail service has been established between Italy and Sicily, in lieu of the former somewhat unsatisfactory combination of railway and ferry. The trip by aeroplane occupies some three hours, and by leaving Naples in the morning the aeroplane can return from Palermo in the early afternoon.

A RECORD RISE IN A SHIPS PRICE.—A ship owner in Gothenburg recently received an offer of a barque at a price of 380,000 kronor: he thought the description fitted a vessel he once had owned, and followed up the matter with the result that the same barque, which was now offered to him at 380,000 kronor, had been sold by him in March, 1914, for 26,000 kronor. (18 kronor = £1 at par).

"A SIMPLE PROBLEM IN FORCED LUBRICATION."

TO THE EDITOR OF ENGINEERING.

SIR,—A correspondent, Mr. W. Pettingill, has pointed out to me an error affecting the latter part of my article on "A Simple Problem in Forced Lubrication," which appeared in ENGINEERING of December 14, page 617.

In equation (13) $d u/d z$ should, of course, have been dv/dz, so that for the moment of the forces due to viscosity

$$M = \frac{\pi \mu \omega}{2 h} (r_1^4 - r_0^4)$$

from which r_0^4 may usually be omitted. Equation (14) must be deleted: and instead of (15) for the whole work done in unit time we have

$$W = \frac{\pi \mu \omega^2 r_1^4}{2 h} + \frac{2 h^3 P^2}{3 \pi \mu r_1^4} \log \frac{r_1}{r_0}$$

Thus W is a minimum by variation of h when

$$h^2 = \frac{\pi \mu \omega r_1^4}{2 P \sqrt{(\log r_1/r_0)}}.$$

Yours faithfully,

RAYLEIGH.

Testing Place, Witham, December 21, 1917.

PRODUCTION OF DUCTILE TUNGSTEN.

TO THE EDITOR OF ENGINEERING.

SIR,—In a lecture given by Mr. Sydney Johnstone at the London School of Economics on the subject of the "Rarer Key Metals," as published in the December 2 issue of *The Daily Telegraph*, the following statement is made with reference to tungsten:—

"A small quantity is employed for the production of filaments for incandescent electric lamps. The manufacture of ductile tungsten for this latter purpose was not carried on in this country before the war."

Mr. Johnstone has evidently been misinformed on this point, because the British Thomson-Houston Company (manufacturers of the well-known Mazda electric lamps) were supplying their whole requirements of ductile tungsten for lamp filaments in 1912 by manufacture at their Rugby works. At that time and until within a month or two from the date of the outbreak of war the raw material used was tungsten oxide, but the company, foreseeing a possible shortage of that material, immediately at outbreak of war, started the manufacture of the metal from the raw ore.

This ore, which is of British origin, has always been available in sufficient quantities to supply the needs of the lamp industry. The metal required for tungsten lamp filaments must be of exceptional purity—far higher than that required for steel alloys—so that the method of refining involved a considerable amount of research and development work before it could be put into regular operation on a commercial scale. This was successfully accomplished, and the whole process of refining the ore and producing ductile tungsten filaments from the metal obtained has now been continuously in operation since the middle of 1915, and many millions of feet of wire have been made.

The British Thomson-Houston Company not only takes care of its own requirements, but supplies filament for lamps made by a number of its licensees. It has sufficient capacity for supplying far more than the requirements of the lamp industry of Great Britain, if needs be. Trusting that you may be able to find space for this letter in an early issue,

We are, Sir, yours faithfully,

(The British Thomson-Houston Company, Limited, Patent Department),

JOHN GRAY.

Mazda House, 77, Upper Thames-street, E.C. 4, December 21, 1917.

"SCIENTIFIC MANAGEMENT."

TO THE EDITOR OF ENGINEERING.

SIR,—I was interested to read your leading article in your issue of the 21st inst. on "Scientific Management." Is it worth while pointing out to you that, without in any way discounting the work of the very able men who have done so much in bringing really scientific methods to bear on the question of saving unnecessary fatigue and increasing the result of effort both material and pecuniary, the whole subject is quite old, and has for many years past been applied and accepted of all aspirants to athletic success.

"Scientific management" is, in athletics, called "coaching." It is applied to football, cricket, lawn tennis, sculling and pretty nearly every other game. Is it too much to hope that wise counsels may yet prevail and that we may "work" "*even as if it were cricket.*"

I am, Sir, your obedient servant,

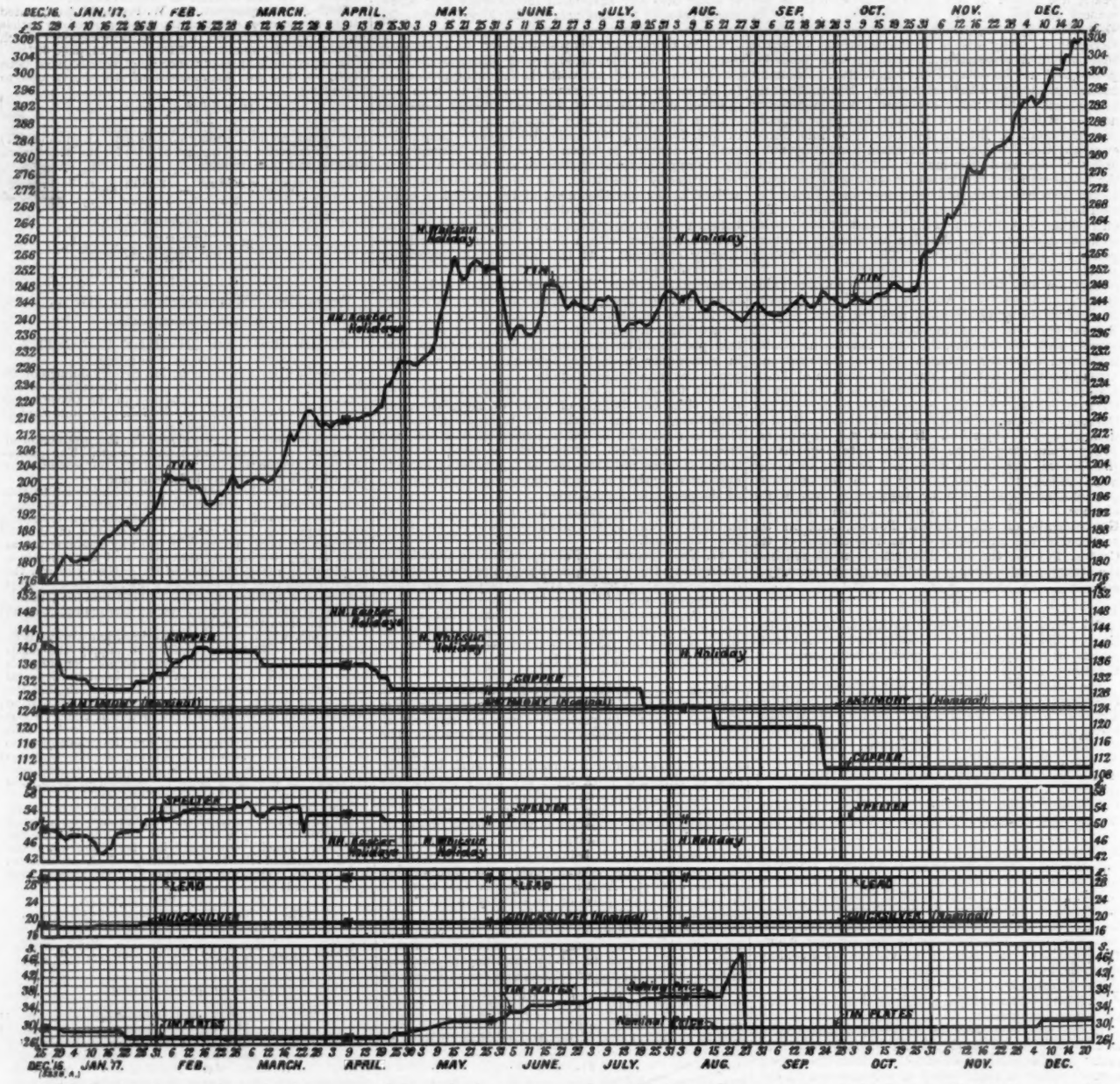
"F.PHYS.SOC.LOND."

London, December 24, 1917.

ECONOMY OF CLEANING BOILER TUBES.—The Electric Light Company, of Worcester, Massachusetts, has installed an electric vacuum system to clean the tubes of a plant of four 150 h.p. five-tube boilers which supply steam and heat to large stores. The cleaner is of the Spencer-turbine type and requires 7.5 h.p. About 500 dols. have been spent for additional tanks, piping and soot removal, the soot being withdrawn (*Electrical World*, September 22, 1917) through a 2-in. pipe with a 4-ft. nozzle: but the saving in fuel is said to amount to 50 dols. per month. The cleaning of a boiler, which may be cold or with banked fires, occupies ten minutes.

DIAGRAMS OF TWELVE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagram above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for antimony and lead are for English metal, whilst those for spelter are for American metal. The prices are per ton, but in the case of quicksilver, however, the price is per bottle, the contents of which weigh about 80 lb. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents two market-days, and the horizontal lines represent 2*l.* each, except in the case of the diagram relating to tin-plates, where they represent 2*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

"Points of Law for Business Men."—The Compendium Publishing Company, of 329, High Holborn, have published an epitome of all the latest decisions (1916–17) of the courts on points of importance to business men. They are grouped under headings of which the chief are: Accidents: adjoining occupiers: admiralty: agents: alien enemies: ancient lights: arbitration: assessment: bankruptcy: banks: carriage of goods: companies: contracts: copyright: debts: excess profits: highways: insurance: international law: landlord and tenant: local authorities: marine insurance: master and servant: mortgages: motor cars: negligence: patents, shipping: trade names: vendor and purchaser: wills: and workmen's compensation. Each judgment is compressed into the fewest words, but complete references are given to the full reports. It is remarkable how many knotty points cropped up last year, and how the law grows, almost daily, as the result of the decisions given. The volume has a full and complete index, so that it can be consulted with ease and celerity. It ought to be the means of saving many from committing themselves by indiscreet action. The price is 5*s.* 4*d.* post free.

Glasgow Draughtsmen.—A meeting of the Glasgow branch of the Association of Engineering and Shipbuilding Draughtsmen, at which about 500 members attended, was held on Friday, December 14, in the Berkeley Hall, Glasgow. The secretary's report disclosed that practically all draughtsmen in the district are now enrolled as members. Finances were stated to be in a satisfactory condition, and the other accounts of the local and national work of the association met with approval. Full discussion took place on the question of registration under the Trade Union Acts, and the delegates of the conference of representatives held in Manchester on December 15 and 16 were instructed regarding the new draught of constitution and rules. A resolution in favour of registration under the Trade Union Acts was unanimously carried. A syllabus of a series of lectures on economic subjects, which are to be delivered in the early part of next year, was submitted. The charge is to be 2*s.* for the course, and the list of lecturers includes such well-known names as Dr. R. A. Duff, M.A., D.Phil., Mr. John Paton, Dr. Cecil H. Desch, D.Sc., D.Phil., and Mr. Thomas Henderson, B.Sc. The meeting decided to record its appreciation of the generous manner in which "Engineering" has recently opened its columns to correspondence on the position of draughtsmen, and to reports of meetings, &c. It may be mentioned that there are now close upon 1,400 names on the books of the Glasgow branch.

DETAILS OF 9-IN. CENTRE HEAVY DUTY SHELL LATHE.

CONSTRUCTED BY THE CINCINNATI LATHE AND TOOL COMPANY, OAKLEY, OHIO, U.S.A.

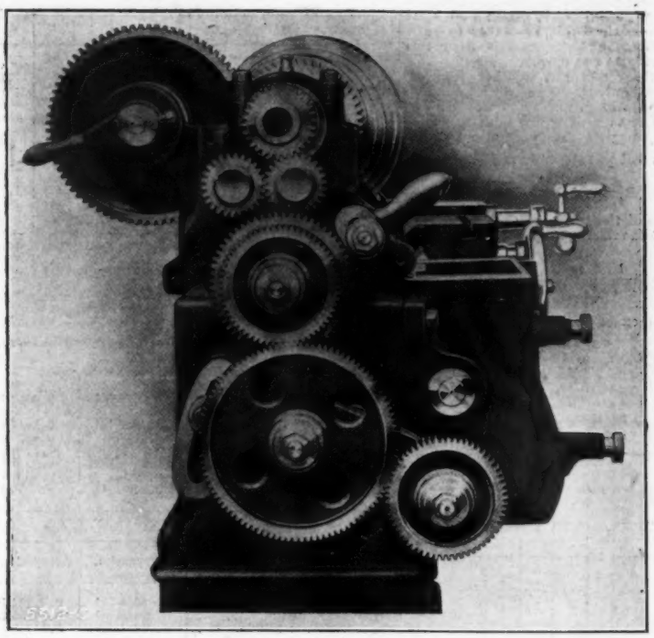


FIG. 5. END VIEW SHOWING REVERSE GEAR FOR CUTTING LEFT-HAND THREADS.

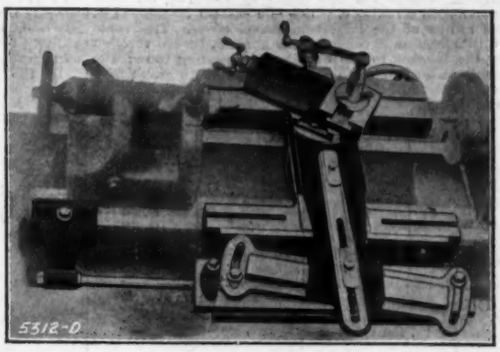


FIG. 6. TAPER TURNING GEAR.

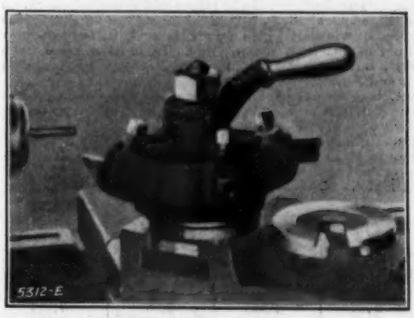


FIG. 7. TURRET FOR EXTERNAL TURNING.

WE illustrate on page 690 and on this page a lathe recently brought out by the Cincinnati Lathe and Tool Company of Oakley, Cincinnati, Ohio, U.S.A., for the rapid production of 6-in. shells. Tested at the makers' works on 6-in. shells of 0.65 carbon steel, the tool was successfully operated at cutting speeds which ranged from 240 ft. per minute at the point to 69 ft. per minute at the extreme diameter. In this test the cut taken was 1 in. on the diameter, or ½ in. on the radius, and the feed was $\frac{1}{3\frac{1}{2}}$ in. per revolution, the running speed of the lathe being 130 r.p.m. The time taken to cut the point of the shell to the exact radius was 16 min. 48 secs. The lathe has 9-in. centres, and is shown in Fig. 1 fitted with a 9-in. universal chuck. The tool post is designed to take the square sections of steel, usually used for tools in this country.

The general character of the lathe is very well shown in Fig. 1. It has a deep bed of semi-steel strongly, braced internally by box section stiffeners. The other castings are of hard, close-grained cast iron. The feed gears, pinions and other gears subject to heavy strains are of steel.

The belt cone has three steps, and powerful backing gearing is provided, as best seen in the end view (Fig. 5, above). The fixed headstock has a spindle of high carbon steel, which is finished by grinding and lapping. It runs in bronze bearings. The thrust is taken on a hardened steel collar, and provision is made for taking up wear when required. The apron, which is illustrated in Figs. 2 and 3, page 690, is rigidly bolted to the carriage. As shown, it is of box construction, thus reducing the number of overhung spindles and studs, all of which, it will be seen, have a double support. The rack pinion is of steel. The longitudinal and cross-feeds have a friction drive, and can be started or stopped or reversed without stopping the lathe, whilst interlocking gear ensures that they cannot be thrown in when the lead screw is being used. To facilitate screw cutting a chasing dial is provided, which permits the half nuts to be opened and the carriage run back by hand, and the thread to be caught up again with ease and certainty at any point whilst the lathe is running. All standard threads can be cut without removing or changing gears, a quick-change gear-box being fitted as shown in Fig. 1.

A view of this gear-box, showing the gears in place, is reproduced in Fig. 4, page 690. All the gears are of forged steel, and they are mounted on very rigid shafting. The bearings are all bronze-lined. The box when assembled forms a complete unit, which can be removed or replaced bodily, without interference with other parts of the lathe. The index plates show at once the position of the change levers necessary for any standard thread. The reverse plate for cutting right and left-hand threads is shown in Fig. 5, above, and is used only for thread cutting, an independent reverse for the ordinary traversing feeds being provided in the apron of the tool. Automatic throw-outs are provided for all the feeds. The carriage is gibbed both front and back, and bears for its entire length on the V's of the bed. The attachment for taper turning is shown in Fig. 6, above. For shell work special guides can be provided which automatically give the proper radius to the head.

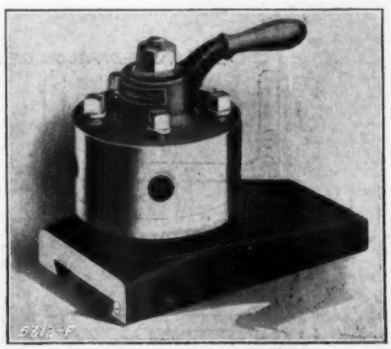


FIG. 8. TURRET FOR INTERNAL CUTTING.

Other special fittings are the turrets, illustrated in Figs. 7 and 8, which can be substituted for the ordinary tool post. These take the ordinary tool-holder bits. They can be attached directly to the compound slide as easily and quickly as an ordinary tool post. The turret represented in Fig. 7 is intended for external turning, and carries four tools, three of square section, and a cut-off tool. For internal work the pattern illustrated in Fig. 8 is provided. This has six 1¼-in. holes. A simple index gear is fitted, which ensures the accurate re-location of the tools on each change of operation.

SHIPBUILDING IN NORWAY.—The Aker Engineering Company is about to commence further extensions, so as to enable the yard to build the largest possible number of vessels of two sizes, 1,800 and 2,500 tons d.w.

THE USE OF SOAP FILMS IN SOLVING TORSION PROBLEMS.*

By A. A. GRIFFITH, M.Eng., of S. Farnborough, and G. I. TAYLOR, M.A., of London.

(*Concluded from Page 655.*)

Approximate Formulæ for Torques and Stresses.—The torque on any section is given by

$$T = N \tau C$$

where C is a quantity of the fourth degree in the unit of length, which may be called the torsional stiffness of the section.

In the case of a circular shaft, in which there is no distortion of cross-sections, C is equal to the polar moment of inertia, so that we have

$$C = \tfrac{1}{2} A r^2$$

where r is the radius of the circle.

In the general case we may put

$$C = \tfrac{1}{2} A k^2$$

k is a length, which, by analogy with the circle, may be called the "equivalent torsional radius" of the section.

It is seen (see appendix, page 701) that the mean stress round the boundary of any section is equal to the boundary stress in a circular shaft whose radius equals the quantity $\frac{2A}{P}$, which we have called h. This result suggested that some fairly simple approximate relation might be found between h and k.

When this idea was tested by application to known results it became immediately evident that the fraction k/h was not very different from unity for a large number of sections. It was observed, however, that the presence of sharp outwardly-projecting corners tended to make k greater than h, while the opposite effect was noticed in the case of sections whose length was great compared with their greatest thickness. For instance, h for the square is equal to a, the radius of the inscribed circle, whereas k is about 6 per cent. greater. In the equilateral triangle h is still equal to a, while k is 9 per cent. greater. For long rectangles and ellipses, however, k is considerably less than h.

At first sight, since, in many sections, these two effects are operating simultaneously, it might be thought that their separation, with a view to formulating a method of finding k empirically, would be a matter of some difficulty. It has been accomplished, however, by a process of successive trial, with the result that the empirical treatment about to be described has been

* Paper read before the Institution of Mechanical Engineers on Friday, December 14, 1917.

evolved. The curves giving the values of the constants were found by plotting the values they should have for all the sections, for which a solution has been obtained, in order to get the correct result, and then drawing the best curves through these points.

If the figure contains sharp, outwardly-projecting corners, construct a new figure by rounding off each corner with a radius r, which is a certain fraction of a, the radius of the largest inscribed circle. The value of this fraction depends on the angle θ, turned through by the tangent to the boundary in passing round the corner in question. In Fig. 3, r/a is shown graphically as a function of θ/π, and, in addition, a table of values is subjoined.

$\frac{\theta}{\pi}$	$\frac{r}{a}$	$\frac{\theta}{\pi}$	$\frac{r}{a}$
0.0	1.00	0.6	0.375
0.1	0.93	0.7	0.270
0.2	0.85	0.8	0.210
0.3	0.75	0.9	0.170
0.4	0.625	1.0	0.155
0.5	0.500		

If the area of this new figure be called A_1, and its perimeter P_1, the value of $\frac{2\,A_1}{P_1}$ is a close approximation to the k of the original boundary, subject to the second modification, which must be made for long sections.

It is not difficult to see that a certain amount of common sense may be required in applying the above rule. For instance, if the figure has a projection which is slightly rounded instead of being quite sharp, the value of r is that which would be used if the projection did run out to a sharp point. In most cases of this sort, however, it is found that the correction makes little difference.

The criterion, which has been adopted for fixing the value of the correction factor for long sections, is the fraction a/h. Where this is appreciably less than unity, the stiffness calculated by the process already described should be multiplied by the correction factor K, which is tabulated below, and which is also shown graphically in Fig. 4.

TABLE VI.

$\frac{a}{h}$	K	$\frac{a}{h}$	K
1.00	1.000	0.70	0.897
0.95	0.998	0.65	0.848
0.90	0.994	0.60	0.793
0.85	0.984	0.55	0.732
0.80	0.966	0.50	0.667
0.75	0.938		

The expression for C now takes the form

$$C = \tfrac{1}{3} K A \left(\frac{2\,A_1}{P_1}\right)^2.$$

This formula is quite satisfactory for figures such as triangles, squares, ellipses, &c., in which a has one maximum value only, which may be called "simple sections," but if a has more than one maximum the solution in its present form is ambiguous, and it is necessary to split the section up into two or more parts, which will be referred to as the "components" of the original figure. The stiffness of each component must be found separately and the total stiffness obtained by addition.

In order to evolve a method of division, it is to be noted that the process already described is based on the equality of the resultant air pressure and surface tension forces acting on the analogous soap film. If the film is divided by a series of "normal septa," which are so arranged that they are everywhere at right angles to the contour lines which they cut, the equilibrium equations are in no way altered, and the theorem is still true of each separate part of the film. Hence, if the section is divided in this way, the empirical treatment explained above should be applicable to each component. It is to be noted, however, that the term "perimeter" must be taken to mean that part of the boundary of the component which formed part of the perimeter of the original figure. The remainder is not, strictly speaking, part of the boundary at all. It remains to formulate rules for the division of these "compound" sections.

Imagine a circle to be drawn in the section so as to touch the boundary at two points. Now let the centre of this circle move through the figure, the radius being varied simultaneously so that there is always contact at two points. At some places the circle will touch at three (or more) points. It is then an "inscribed circle of maximum radius," and between every such pair of maxima there must be a position where the radius is a minimum. The section should be divided by straight lines passing through the points of contact of these minimum circles.

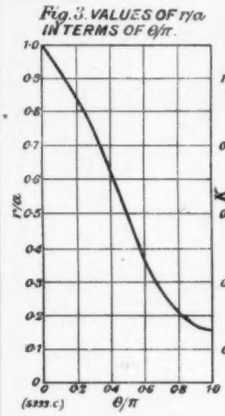
In some cases, such as the web of an I-beam, there is a long thin parallel portion, and the position of the minimum circle is indeterminate. Here the line of division should be at a distance from the commencement of the parallel part equal to half its thickness. The portion of the web cut out may be treated separately as part of an infinitely long, thin rectangle, the torsional properties of which are well-known. If the piece cut off is "closed" at the other end (*e.g.*, the arm of an angle), it may be treated as a separate component. It is advisable to cut off all long, thin, projecting parts, in the same way, even though the sides are not quite parallel. The tapering flanges of I-beams may be cited in illustration.

Fig. 5 shows some typical examples of the subdivision of compound sections, and also illustrates the rounding-off of sharp corners. The I-beam, for instance, has seven components, the channel five, and the tee four. In the 45 deg. sector there is only one component. The angle turned through at the apex is 135 deg., so that $\theta/\pi = 0.75$. Hence, from the Table, $r = 0.24\,a$ (a is the radius of the chain-dotted circle). At the other two corners $\theta/\pi = 0.5$, and hence $r = 0.5\,a$.

In the case of certain sections, another form of expression may be arrived at, by a more direct method. Consider a soap film on a long, narrow slit of varying width. If the rate of change of width with length is nowhere large, we may neglect the longitudinal curvature, $\frac{\delta^2 z}{\delta x^2}$, of the film, and put the transverse curvature $\frac{\delta^2 z}{\delta y^2}$ equal to a constant R, say, if the width at a distance x from one end be y, and the total length l, we readily obtain the volume V of the film in the form

$$V = \frac{1}{12\,R}\int_0^l y^3\,dx$$

This result may be exact for an indefinitely long



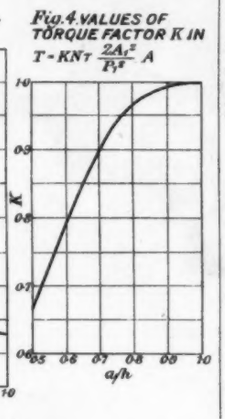
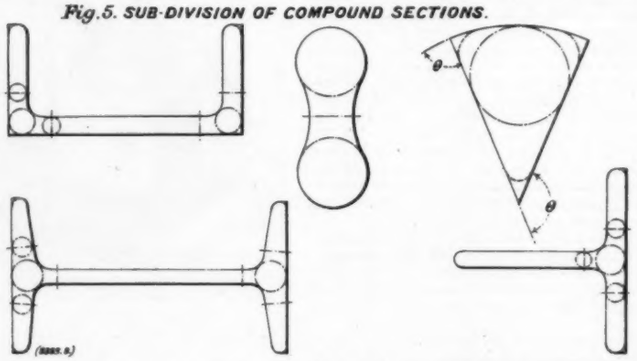


Fig.5. SUB-DIVISION OF COMPOUND SECTIONS.



rectangle, whence we have, by comparison with the known stiffness of the latter,

$$C = \frac{1}{3}\int_0^l y^3\,dx = I, \text{ say,}$$

for the torsional stiffness of any long, thin section.

A consideration of the case of ellipses suggests the modification

$$C = \frac{1}{1 + 4\,\frac{I}{A\,l^2}}$$

to allow for the longitudinal curvature of the figure.

The expression is now exact for all ellipses, whatever their fineness ratio, and, as will be seen, its error is within the limits of accuracy of soap-film measurements, for sections such as those of airscrew blades, down to a fineness ratio of two, at least.

The formula may also be applied, though with somewhat less accuracy, to thin sections having a curved median line, provided that x is measured along the latter and y at right angles thereto.

Tables VII, VIII and IX have been prepared to indicate the degrees of accuracy which may be expected in the application of the above formulæ.

In Table VII, comparison is made with the results of Saint Venant's exact analysis: in Table VIII the second column of values has been obtained from soap-film measurements: while on Table IX the results of the method are compared with those of some direct torsion experiments on rolled beams, carried out by Mr. E. G. Ritchie.*

It will be seen that all the figures in Table IX show

TABLE VII.

Section.	C (formula).	C (calculated).	Error
			per cent.
Square : Side $2s$	$2.249 s^4$	$2.249 s^4$	0
Rectangle : Sides, $2b$, $3b$ ..	$4.710 b^4$	$4.698 b^4$	+0.26
,, ,, $2b$, $4b$ ..	$7.320 b^4$	$7.318 b^4$	−0.03
,, ,, $2b$, $10b$ ..	$23.15 b^4$	$23.31 b^4$	−0.68
,, ,, $2b$, $2l$ $l \to \infty$ ..	$\frac{16}{3} lb^3$	$\frac{16}{3} lb^3$	0
Ellipse : Axes, $2b$, $3b$	$3.250 b^4$	$3.260 b^4$	−0.31
,, ,, $2b$, $4b$	$5.035 b^4$	$5.025 b^4$	+0.20
,, ,, $2b$, $10b$.. ..	$15.14 b^4$	$15.10 b^4$	+0.26
,, ,, $2b$, $2l$ $l \to \infty$ ..	$3.235\ lb^3$	$\pi\ l\ b^3$	+3.00
Equilateral triangle : Side $2s$..	$0.3476 s^4$	$0.3464 s^4$	+0.27
45 deg sector : Radius R ..	$0.01810 R^4$	$0.01815 R^4$	−0.27
90 deg. sector : Radius R ..	$0.0839 R^4$	$0.0824 R^4$	+0.73
Curtate sector : 180 deg., $R_1 = 2R_0$	$1.355 R^4$	$1.369 R_0^4$	−1.02

TABLE VIII.

Section.	C (formula).	C (soap film).
Wing spar : 2½ in. × 1½ in. (I-section)	0.0678 in⁴	0.0680 in⁴
Wing spar : 3 in. × 1½ in. (I-section)	0.1042 in⁴	0.1051 in⁴
Angle : 3 in. × 3 in.	0.478 in⁴	0.487 in⁴
Airscrew section : A	11.70 in⁴	11.72 in⁴
,, ,, B	7.44 in⁴	5.50 in⁴
,, ,, C	2.42 in⁴	2.38 in⁴
,, ,, D	0.846 in⁴	0.835 in⁴

TABLE IX.

Section.	C (formula).	C (experiment).
Angle : 1.175 in. × 1.175 in. ..	0.01234 in⁴	0.01284 in⁴
1.00 in. × 1.00 in.	0.00440 in⁴	0.00455 in⁴
Tee : 1.58 in. × 1.58 in. ..	0.01451 in⁴	0.01481 in⁴
I-beam : 5.01 in. × 8.02 in. ..	1.160 in⁴	1.140 in⁴
,, 3.01 in. × 3.00 in. ..	0.1179 in⁴	0.1082 in⁴
,, 1.75 in. × 4.78 in.. ..	0.0702 in⁴	0.0635 in⁴
Channel : 0.97 in. × 2.00 in.	0.0175 in⁴	0.0139 in⁴

good agreement with the exception of those referring to the last three beams. In view of the remarks made by the author cited in regard to the want of homogeneity of rolled beams, and more particularly the comparative weakness of the metal in the internal radii, the discrepancy in these cases cannot be considered unsatisfactory.

The method of calculating C should be chosen according to the nature of the section.

If there is only one maximum inscribed circle, and the section is not a long thin one, proceed by the method of rounding off sharp corners and finding $\frac{2\,A_1}{P_1}$, &c.

If the section is compound, divide it into its components and then proceed as before. Alternatively, if some of the components are thin compared with their length, they may be dealt with by finding $\int y^3\,dx$.

If the median line of the section is long in comparison with the greatest thickness, straighten out the median line where necessary and use the $\int y^3\,dx$ method.

Estimation of Stresses.—The empirical calculation of the stress at any given point of a section is naturally a matter of greater difficulty than the determination of torques. If the section contains no re-entrant angles, the stresses at the three points of contact of the inscribed circle of maximum radius a are usually given sufficiently well by the expression

$$\frac{2\,a}{1 + m^2}\left[1 + 0.15\left(m^2 - \frac{a}{\rho}\right)\right].$$

* "A Study of the Cricular Arc Bow Girder," by Gibson and Ritchie. (Constable and Co., 1914.)

where m is the quantity $\frac{\pi a^2}{A}$ and ρ is the radius of curvature of the boundary.

In the case of a "compound" section, the formula may be applied to each component separately.

The mean value of the stress round the boundary of any component is accurately equal to $2 N \tau \frac{A}{P}$. By combining this value with those obtained for the maximum stresses, and bearing in mind the general properties of soap films, it is possible to sketch in a boundary stress diagram for the component, with sufficient accuracy for most purposes.

TABLE X.

Section.	Stress/N τ (formula).	Stress/N τ (true).
Ellipse: Axes $2a$, $2b$	$\frac{2ab^2}{(a^2+b^2)}$	$\frac{2ab^2}{(a^2+bc)}$
Square: Side $2s$	1.35s	1.35s
Rectangle: Sides $2s$, $3s$	1.64s	1.69s
,, ,, $2s$, $4s$	1.77s	1.86s
,, ,, $2s$, $8s$	1.94s	1.99s
,, ,, $2s$..	2.00s	2.00s
Equilateral triangle: Sides $2\sqrt{3}s$ ..	1.53s	1.50s
Wing spar (I) a = 1.05 in. ..	2.14	2.13*
,, ,, (I) a = 1.27 in. ..	2.60	2.58*

* Determined by soap films.

Obviously the formula cannot be expected to apply to points where the boundary is concave that is, re-entrant angles, since it fails to differentiate between an acute re-entrant angle and an obtuse one. It is possible to devise a formula which will take account of this angle and which will fit any assigned number of observed results within, say, 4 per cent. or 5 per cent., but such a formula naturally becomes more complicated as its range of application is increased, and hence the practical utility of such generalisation is doubtful. Probably the most satisfactory way of dealing with re-entrant sections is to make soap film measurements and to deduce, from these, formulæ or curves which apply to one particular class of figure only.

It should be mentioned, however, that the formula given has been found to agree with soap-film measurements on a number of re-entrant sections, in which the angle is approximately a right angle, when ρ is not very small. I-beams, channels and tees are examples of such sections, to which the formula may be applied. It should be borne in mind, however, that ρ is now negative.

The stress at any point of a rolled standard section may be taken to be $2 a N \tau$, where a is the radius of the inscribed circle which touches at that point, except at places near the end of a flange, where the stress is smaller. The same thing holds for figures such as aircrew sections, when the fineness ratio is greater than about eight.

MATHEMATICAL APPENDIX.

The solution of the problem of torsion can be made to depend (see the book referred to in the introduction) on the finding of a function, ψ of x and y, the co-ordinates of points on the cross-section, which satisfies the partial differential equation

$$\frac{\delta^2\psi}{\delta x^2} + \frac{\delta^2\psi}{\delta y^2} + 2 = o \quad . \quad . \quad . \quad (1)$$

at all points of the cross-section, and is zero at all points on the bounding curve.

Consider the equations which represent the surface of a soap film stretched over a hole of the same size and shape as the cross-section of the twisted bar, cut in a flat plate, the film being slightly displaced from the plane of the plate by a small pressure p.

If S be the surface tension of the soap solution, the equation of the surface of the film is

$$\frac{\delta^2 z}{\delta x^2} + \frac{\delta^2 z}{\delta y^2} + \frac{p}{2S} = o. \quad . \quad . \quad . \quad (2)$$

where z is the displacement of the film and x and y are the same as before. Round the boundary, of course, $z = o$.

It will be seen that if z is measured to such a scale that $\psi = \frac{4Sz}{p}$, then the two equations are identical.

It appears, therefore, that the value of ψ corresponding with any values of x and y can be found by measuring the quantities p/S and z on the soap film.

To put the matter in another light, the soap film is a graphical representation of the function ψ for the given cross-section. Actual values of ψ can be obtained from it by multiplying the ordinates by $\frac{4S}{p}$.

If N is the modulus of rigidity of the material and τ the twist per unit length of the bar, the shear stress at any point of the cross-section can be found by multiplying the slope of the ψ surface at the point by $N\tau$, so that, if γ is the inclination of the bubble to the plane of the plate, the stress is

$$f_s = \frac{4S}{p} N \tau \gamma \quad . \quad . \quad . \quad . \quad (3)$$

The torque T on the bar is given by

$$T = 2N\tau \iint \psi \, dx \, dy$$

or

$$T = \frac{8S}{p} N \tau V \quad . \quad . \quad . \quad . \quad (4)$$

where V is the volume enclosed between the film surface and the plane of the plate.

The contour lines of the soap film in planes parallel to the plate correspond to the "lines of shearing stress" in the twisted bar, that is, they run parallel to the direction of the resultant shear stress at every point of the section.

It is evident that the torque on and stresses in a twisted bar of any section whatever may be obtained by measuring soap films in these respects.

In order to obtain quantitative results, it is necessary to find the value of $\frac{4S}{p}$ in each experiment. This might be done by measuring S and p directly, but a much simpler plan is to determine the curvature of a film, made with the same soap solution, stretched over a circular hole and subjected to the same pressure p between its two surfaces, as the test film.

The curvature of the circular film may be measured by observing the maximum inclination of the film to the plane of its boundary.

If this angle be called μ, then

$$\frac{4S}{p} = \frac{h}{\sin \mu} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where h is the radius of the circular boundary.

The most convenient way of ensuring that the two films shall be under the same pressure, is to make the circular hole in the same plate as the experimental hole.

It is evident that, since the two films have the same constant $\frac{4S}{p}$, we may, by comparing inclinations at any desired points, find the ratio of the stresses at the corresponding points of the cross-section of the bar under investigation to the stresses in a circular shaft of radius h under the same twist. Equally, we can find the ratio of the torques on the two bars by comparing the displaced volumes of the soap films. This is, in fact, the form which the investigations usually take.

As a matter of fact, the value of $\frac{4S}{p}$ can be found from the test film itself by integrating γ, its inclination, round the boundary. If A be the area of the cross-section, then the equilibrium of the film requires that

$$\int 2S \sin \gamma \, ds = pA \quad . \quad . \quad . \quad (6)$$

This equation may be written in the form

$$\frac{4S}{P} = 2 \times \frac{\text{area of cross-section}}{(\text{perimeter of cross-section}) \times (\text{mean value of } \sin\gamma)} \quad (7)$$

By measuring γ all round the boundary the mean value of $\sin\gamma$ can be found, and hence $\frac{4S}{p}$ may be determined. This is, however, more laborious in practice than the use of the circular standard.

It is evident that if the radius of the circular pole be made equal to the value of $\frac{2A}{P}$, where A is the area and P the perimeter of the test hole, then $\sin\mu$ = mean value of $\sin\gamma$. It is convenient to choose the radius of the circular hole so that it satisfies this condition in order that the quantities measured on the two films may be of the same order of magnitude.

The corresponding theorem in the torsion problem states that the mean stress round the boundary of a twisted bar is equal to the stress at the boundary of a circular shaft of radius $\frac{2A}{P}$. It is shown in the text that this property can be made the basis of a method of approximating to the torsional stiffness of any bar by calculation.

SYMBOLS AND FORMULÆ USED IN THE PAPER.

N = modulus of rigidity of material.
τ = twist of bar in radians per unit of length.
A = area of cross-section of bar.
P = length of perimeter of cross-section.
$h = \frac{2A}{P}$.
f_s = shear stress in bar.
f_c = shear stress in circular bar of radius h under twist τ.
T = torque applied to bar.
T_1 = torque applies to circular bar to give twist τ.
γ = inclination of soap film blown on a hole of the same shape as the twisted bar.
μ = inclination of film blown on a circular hole of radius h.
V = displaced volume of the test-film.
V_1 = displaced volume of the circular film.
S = surface tension of soap solution.
p = pressure difference causing displacement.
$C = \frac{T}{N\tau}$.
k = "equivalent torsional radius."
a = radius of inscribed circle.
r = radius for rounding projecting corners.
θ = angle turned through at a corner by the tangent to the boundary.
A_1 = area of modified section, when the corners have been rounded off.
P_1 = perimeter of modified section.
K = torque correction factor.
$I = \frac{1}{3}\int_0^l y^3 \, dx$, the integration being taken along the median line of the section (l = length of median line).
$m = \frac{\pi a^2}{A}$.
ρ = radius of curvature of boundary of section.

(1) $f_s = \frac{4S}{p} N\tau\gamma$.

(2) $T = \frac{8S}{p} N\tau V$.

(3) $\frac{4S}{p} = \frac{h}{\sin\mu}$

(4) $\frac{f_s}{f_c} = \frac{\sin\gamma}{\sin\mu}$, for any pair of points on the sections.

(5) $\frac{T}{T_1} = \frac{V}{V_1}$

(6) $C = \frac{1}{2} KA\left(\frac{2A_1}{P_1}\right)^2$ for a simple section or for any component of a compound section.

(7) $C = \frac{I}{1 + \frac{4I}{A l^2}}$ for a long thin section.

(8) Stresses at points of contact of inscribed circles of radius a

$$f_s = \frac{2aN\tau}{1+m^2}\left[1 + 0.15\left(m^2 - \frac{a}{\rho}\right)\right].$$

(9) Mean stress round the boundary of any section

$$f_s = \frac{2A}{P} N\tau.$$

(10) Stress at any point of the boundary of a rolled standard section $f_s = 2aN\tau$

(a is the radius of the inscribed circle which touches at the point in question)

BUENOS AIRES WESTERN RAILWAY TUNNELS UNDER THE CITY OF BUENOS AIRES.*

By WILLIAM LOWE LOWE BROWN, M.Sc., M.Inst.C.E.

THE works described are :—

(*a*) A concrete-lined single-line tunnel about 3 miles long, giving the railway a direct connection for goods traffic only between their main line and the port.

(*b*) A double-line tunnel, about two-thirds of a mile long, to bring the suburban passengers into an underground interchange station, in which they can conveniently change to the trains of an underground line running into the heart of the city.

The paper gives a short description of the City of Buenos Aires and of the traffic of the Western Railway, and then explains that the railway had no connection of its own with the port, and had in consequence to send all goods consigned there over other railways, at a cost of about 35,000*l.* a year. As a tunnel access to the port would pass through the heart of the city, and as the existing passenger terminus was not conveniently situated for the suburban passengers, it was natural to consider improving the facilities for this service at the same time.

A short history of the present project is next given. Originally it had been proposed to build a double-line tunnel to the port to be used for both the goods and passenger service, with passenger stations at suitable points on the route: but the idea was afterwards changed for various reasons, principally because the tramway company obtained a concession for an underground line which followed the same route and could be built under more favourable conditions. It was, therefore, decided to build only a single-line tunnel to the port exclusively for the goods service, and to construct jointly with the tramway company an underground interchange station on the tramway company's underground line into the heart of the city, with a short double-line tunnel connecting it to the railway company's main line.

The route taken by the tunnels and the layout of the interchange station are next described: the different types of station considered are discussed in relation to the probable traffic, which, although only about 5,000,000 passengers per annum at the time the studies were commenced, was expected to increase to about 20,000,000 within a very few years of opening the service. In the adopted scheme for the interchange station the railway company's tracks occupy the middle position in the station, and are separated from the tramway company's by two wide island platforms, one on each side. The passengers change trains by simply walking across these platforms.

Before describing the design of the tunnel lining, a description of the extremely favourable nature of the subsoil for tunnelling is given, and the steps taken to prove its reliability and continuity are explained: the ground is a sort of clayey marl, but does not appear to have any of the treacherous qualities of clay or marl: in fact, it is more like soft rock than anything else, as it will stand untimbered for a long time without any sign of movement. The underground obstructions to be met with are next described: they consisted not only of sewers, &c., crossing the route, but also of the tramway company's underground line, which was to be constructed at the same time almost immediately above the goods tunnel for the greater part of its length, and was at most points actually constructed before the tunnel.

The adopted design for the goods tunnel is a horseshoe-shaped mass-concrete lining, 1 ft. 8 in. thick, large enough to accommodate the standard Argentine broad gauge (5 ft. 6 in.) railway, the construction gauge of which is 15 ft. 10 in. high and 13 ft. 9 in. wide. A cast-iron lining was considered, but was rejected on account of cost. The design for the passenger tunnel was also a mass-concrete lining, but for a double line.

In describing the construction, the positions of the working shafts are explained, and the general plant at

* Abstract of paper read before the Institution of Civil Engineers on Tuesday, December 18, 1917.

each working site is described. Owing to the design, very simple methods of construction were possible, and the plant was of the simplest nature: all the excavations and concreting were done by hand. The general sequence of operation is explained by means of sketches. Very little timbering was necessary, the contractors taking advantage of the good ground by working in much longer lengths than was originally contemplated.

GERMAN INDUSTRIAL ENTERPRISE.

In spite of the war, or rather perhaps owing to the exceptional profits some of the large industrial concerns in Germany have succeeded in earning during the war, extensions, increase of capital and large combines are comparatively frequent.

Prominent amongst these enterprising concerns is that of the Rhenish Steel Works; only this last May it increased its coal-mining property by the purchase of the Brassert Gewerkschaft, at the price of 21,000 marks per portion (kux), the capital being then increased from 48,000,000 marks to 60,000,000 marks. Now a still larger deal has been accomplished by the same company, the Friedrich Heinrich coal-mining concern having been acquired, the share capital of the latter being 22,000,000 marks. Of this total 20,500,000 marks were in the possession of French holders, and at the compulsory reclisation of the French shares the Rhenish Steel Works made the highest bid of 183 per cent., at which price the company has now become possessed of the shares, it being arranged that the purchase sum, about 37,500,000 marks, shall be paid in cash. No fresh issue of shares will take place at present, the sum being covered partly by the company's substantial funds in hand and partly through a bank loan. The company has also offered to purchase the remaining 1,500,000 marks shares, in German possession, at the same price of 183 per cent., an offer which holds good for several months. By the acquisition of the above-mentioned coal-mining concerns the Rhenish Steel Works have risen to the front rank of the large mixed undertakings (iron and steel and coal), and will stand on a similar level to that of the Gutehoffnungshütte: it will more especially increase its production of coke, which hitherto has been somewhat unimportant.

Whilst the fate of the Friedrich Heinrich concern has thus been sealed, that of the de Wendel, Hayingen, Steel and Iron Works is still proceeding. This is a much larger concern, having not less than between 400,000,000 marks and 500,000,000 marks; but compulsory liquidation has been decreed, the owners being French subjects. As the property cannot be divided, and as no concern will be likely to take it over single-handed, several schemes have been suggested and discussed. Neither August Thyssen, who once before had endeavoured to procure an adequate iron ore basis for his Hagendinger works through a combination with de Wendel, nor the German Luxemburg Company, nor the Rombach concern, which all have been mentioned as desirous of securing the Hayingen undertaking, can at present muster the necessary funds. The Prussian State, which, as a State, boasts the widest experience as mining expert, is to some extent put out of court by most of the property being situated in Lorraine and only a portion, principally mines, in Prussia (Westphalia). The steel industry seems to be against the State taking over the concern in question, arguing inability on the part of the State as regards manufacture of steel and iron, an objection which has been met from other quarters with the reply that the State can secure the services of as able experts as private concerns. On the other hand, Alsace-Lorraine is hindered in the same way as Prussia by part of the property being within the latter country. The German Empire of course embraces the whole of the de Wendel undertaking, but so far the Empire, apart from industries resulting from the war, has not managed any industrial concern. Then there is the German Steel Union, but against this solution the objection might be, and has been, raised that the steel union lacks the necessary stability—its unbroken existence cannot be reckoned with as a fixed certainty. As a substitute it has been recommended that the Hayingen works be taken over by a limited company, the shares to be taken over by the members of the Steel Union. But others do not consider this limitation a fair one, as the Hayingen works do not confine their manufacture to that of steel, but also have blast-furnaces and produce finished goods. As an outcome of all these considerations a limited company has been recommended as the best and most rational way out of the difficulty, or a syndicate in which all steel and iron industries that wanted to, could become interested, in addition, perhaps, to some banks and State exchequers.

The Gewerkschaft Westphalen has at last succeeded in purchasing the Anneliese Coal Mining Company, for which also the Mansfeld mining concern was a bidder, as was also the large concern of Georg von Giescheserben. The latter, however, owns the greater part of the Westphalen concern, the rest being held by the Harpen Company, which, prior to the sale, owned 261 portions of the Anneliese concern; the price for the latter was 7,800,000 marks.

Some sensation has been created by the fact that the Daimler Motor Company is about to quadruple its capital, from 8,000,000 marks to 32,000,000 marks, as new and very important work is in store for the company, with regard to the nature of which nothing, however, has been allowed to transpire. The Daimler Company has pursued a consolidation policy which is described as almost surpassing the permissible, inasmuch as all the company's land, buildings, machinery, shares in other concerns, &c., have been entirely written-off. The shareholders have repeatedly, and apparently not without cause, clamoured for higher dividends, and although the dividend did rise from 16 per cent. in 1914 to 28 per cent. for 1915, and 35 per cent, for 1916, it represents only a comparatively small portion of the profits. The new capital will be offered to the shareholders at a little above the nominal value, which, of course, means a most substantial bonus. As a plea for keeping the dividend down the view has been put forward by the board that too high dividends might induce the men to hold out for higher wages. The Daimler Company is not the first lucrative concern which has adopted the method of large increases of capital in order partly to screen the amount of its huge profits being gauged by the dividend. Profits must indeed be exorbitant when companies, after having reserved perhaps half of their earnings for war profit taxation, yet feel shy at disclosing their real earnings.

The Langscheder Rolling Mills are also increasing their capital, nominally, by presenting their shareholders with a free share for every nine old shares, and these shares are paid for out of the surplus of last year; in addition the shareholders, besides a dividend of 15 per cent., receive a bonus of 5 per cent., which, taking the new shares at their nominal value, means 30 per cent., against 5½ per cent. for the preceding years. Prospects for the current year are stated to be very satisfactory.

The report of the important Hohenlohe Works shows continued consolidating endeavours, with material writings-off, so that the zinc ore mines will be written completely off, if the same sums are applied, within 3½ years, whilst their life is calculated at twice that time; they now stand booked at 12,000,000 marks, against 26,000,000 marks at the end of the year 1912–13. The zinc ore deposits in Norway now stand booked at 200,000 marks, against 2,045,306 marks five years ago. Coal mines in working now stand booked at 46,800,000 marks, against 57,900,000 marks five years ago, &c. During last year the company has subscribed 4,000,000 marks war loan. The report says that the demand for coal has been active throughout the year, but since the autumn of 1916 there has been a constant shortage of rolling-stock, so that deliveries could not keep pace with the demand; production was hampered, and the cost of production correspondingly increased, without any adequate increase in prices. Matters have mended somewhat during the current year, both as regards transport accommodation and prices for coal and zinc. During the last financial year the new pit at Oehringen was carried down to a depth of 191.5 m., and the new pits at Sosnitza, pits 1 and 2, to 107.5 m. and 76 m.

The Becker Steel Works have deemed it advisable to increase their writings-off, the sum for last year being 3,305,689 marks, against 1,506,646 marks for the previous year, and 2,404,764 marks has been reserved for war-profit taxation. The net profits amount to 4,956,001 marks, against 3,276,214 marks for the previous year. The dividend was reduced from 30 per cent. to 25 per cent., the capital having in the meantime been doubled, from 8,000,000 marks to 16,000,000 marks.

The United Steel Works van der Zypen and Wissen Iron Works, at Deutz, have, during last year, started a new blast-furnace, which had been in course of building since 1913, and a blast-furnace at the Heinrichshütte has been lighted again, so that all four blast-furnaces are now in operation. The number of hands employed at the steel works had risen from 2,683 to 3,280 hands, at the iron works from 547 to 622, and at the mines from 1,702 to 1,787 on an average. The demand was satisfactory in all branches.

CATALOGUES.

Heavy Motor Vehicles.—A very clean-built and powerful vehicle is shown in a catalogue issued by Messrs. Clayton and Co., Huddersfield, Limited, of Huddersfield, Yorkshire. It carries a burden of 5 tons and conforms to War Office specification. Petrol engines are fitted of 50 h.p., with four cylinders of 5-in. bore and 6-in. stroke, the normal speed being 1,000 r.p.m. The road speeds are 12 m.p.h., 7 m.p.h., 4½ m.p.h. and 2 m.p.h., allowing for work in very hilly country. The whole design is specially and thoughtfully worked out, and all the material and work is of high quality, so that it is evident that manufacturers have confidence in the commercial future of the petrol-engined goods vehicle.

Marine Engines.—We have received from Messrs. Richardsons, Westgarth and Co., Limited, of the Hartlepool engine works, a copy of their standard specification for triple-expansion marine engines. This specification is in accordance with the North-East Coast guidance specification published this year, and includes the special requirements of Messrs. Furness Withy and Co. Bound up into one volume with this specification is much important additional matter. Thus, one section gives the North-East Coast standard outfit, another the standard demarcation of work between engineers and shipbuilders, whilst in a fourth section the "Contraflo" system of auxiliaries is described in detail, and with the aid of a number of excellent illustrations. The volume concludes with a reprint of the North-East Coast guide specification. It will be seen that the publication will prove of service to a wide field of readers.

Spring Coiling Machines.—A series of machines for coiling wire into spring forms are illustrated and described in a catalogue issued by Messrs. Sleeper and Hartley, of Worcester, Mass., U.S.A., and 63, Queen Victoria-street, London, E.C. 4. One of the machines will work wire of diameters from 0.034 in. to 0.135 in., making coils at the rate of 35 per minute to 100 per minute with parallel, tapered, coned or barrelled length shapes and with either constant pitch or closer coiling at one or both ends. For dealing with square wire, special attachments are supplied. Other machines are shown for setting, grinding, hooking and knotting springs: cutting, flattening and straightening wire: coiling for flexible tubing and shafting and making wire nails, tacks and staples. The action of the machines is not fully described, but many illustrations of coils and other products are given. The machines take very little floor space.

Aircraft Fittings.—The Aircraft Supplies Company, Limited, 125, Long Acre, London, W.C. 2, publish a periodical catalogue of their stock of standard parts, tools, &c. Dimensions, prices and quantities offered are stated, and in many cases illustrations and drawing numbers are given. The State department for aeronautical supplies has made such catalogues more complicated than they need be by introducing a system of stating the length of bolts in alphabetical terms. The official name for a common bolt is "A.G.S. 105.E." How this formula conveys comfort, convenience or illumination to the hotel official is not known: but the mechanic, storekeeper and draughtsman still think of bolts in terms of the diameter, length, screw and shape of head. In the formula quoted "E" signifies 2 in. long, and the standard lengths vary by fifths of an inch until 3 in. is reached, and then by quarters of an inch up to 6 in., which consumes the English alphabet as far as Y. It is compulsory to use the official designation and necessary to use the commonsense one, so that quite a remarkable amount of extra employment is created.

Farm Engines.—The farm horse averages 3½ hours' work per day, and eats the produce of 5 acres of land in a year—that is how the case against him is stated by the makers of a mechanical horse. The indictment is probably true, but it should be couched in more kindly terms. With all our mechanical horse-power we still want more horses and better horses than ever. Undismayed by all our tanks and tractors the horse, like a good workman, has always found a better job than the one we ousted him from. The catalogue in hand deals with a paraffin engine (starting on petrol) mounted on four wheels and capable of drawing a plough with two to four shares, and adapted for working mowing, binding, harvesting or any land-surface working machine, or for use as a stationary engine delivering a belt drive. The horse-power is 24 indicated and 12 at the drawbar. The designers have very boldly and wisely disregarded consideration of appearance and given a substantial and accessible mechanical form, resulting in the most useful, honest and ungainly creation imaginable. The fuel consumption is given at 2 gallons of petrol per week for starting (2 minutes to 3 minutes run per start), while the regular fuel, a cheap grade paraffin, costs, assuming 10*d.* per gallon as the price, 20*d.* per acre for ploughing, 12*d.* per acre for mowing grass, 9*d.* per acre for harvesting, 15*d.* per hour threshing, 8*d.* to 12*d.* per hour chaff-cutting, &c. The machine is apparently American made, but large premises have been taken in East London for assembling, storage and repairs, and a full stock of spare parts and accessory machines is kept there. The catalogue is issued by the Overtime Tractor Company, 124, Minories, London, E. 1.

THE END OF THE ONE HUNDRED AND FOURTH VOLUME.